POWER

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CANDID CHATS

Be Ready—Aye Ready For What?

"I am sorry, sir. No. 4 valve in the header line looks as if it will burst, and I shall have to shut down for a short time."
"Umph! How long will you be?"
"Can't say exactly." "What caused it?"
"I don't know. The face has been cracked for some time and I had a clamp on it, but it has suddenly gone back on me and I am not sure if I have a face the same size or not."

IS THAT the way you have to talk to the boss, and do you just patch a job like this man and leave it till it breaks again? Would you have to say you had no idea how long it would take to make a repair, or could you say, "I was half expecting it to go, but wanted it to last as long as possible. It will take 20 minutes to put on the rough clamp I have ready, and I will have it fixed properly tonight."

That's it—Get a makeshift at once and keep the wheels going around during working hours, even if it means a wooden piston. BUT see that your mechanics take off the patch THAT SAME NIGHT and make a good job at once. You may have two patches and they may both give out at once. Makeshifts spell worry and no peace of mind. What does it matter if you are asked, "Why this increase of 100 hours overtime to mechanics?" When you can answer, "Stoppages due to power-plant trouble, down 10 hours." One hour of factory time lost is equal to how many hours of individual mechanics' time? Calculate it for your plant. It's worth knowing.

What's going to break down next in your plant? And what are you going to do about it? Are you ready for it? Have you been going around looking for things that might break? Many a man in so doing has found to his surprise that if he did not give something his immediate attention it would soon break—and that was one less stoppage to report.

Is it your habit to inspect the insignificant things in your plant every Wednesday and decide what to do when they go wrong? Have you a drawing of all their sizes?

If you are rung up at night because of a breakdown, can you say offhand what men are to be called out and what is to be done immediately? Or are you all of a fluster until you get to the works and then decide? The best way always takes some thinking. How often does an engineer say, "If I had that to do over again I could do it in half the time and keep the mill going, too."

Many men have been given good positions simply on the strength of the way they were seen to tackle an unexpected (?) breakdown. Someone happened to be looking on. Is there any chance of anyone seeing you?

How about that arrangement in your plant which you do not like because it is awkward and uneconomical but too costly to change. If it should break down or get out of order, is there a drawing and an estimate in your desk of a new way to do the same thing which would convince your superior that the extra money spent in installing it instead of repairing the old arrangement would repay him—and give you peace of mind? Or would you have to figure this out while the factory is idle, and since the repairing would be quicker, would the old thing remain?

Perhaps your feed pump is worn out. Which new kind have you decided on, and where is it to be put? Are you waiting for it to give way, and then will you have to put in the quickest one that can be got and in the easiest place? Or is that drawing in your desk? Propositions of this kind brought forward at the psychological moment often get passed easily—if they are complete and definite

Contributed by SYMINGTON McDONALD, JR., *Glasgow, Scotland*

Rejuvenation of the Power Plant of United Illuminating Co.

By J. Breslav

SYNOPSIS—An account of the unusual difficulties encountered, the manner in which they were overcome and how one of the oldest central stations in New England was turned into one that ranks among the best.

When in the winter of 1914 the management of the United Illuminating Co., of New Haven, Conn., decided to abandon their direct-current station in the center of the city and more than double the capacity of their waterside station, they gave their superintendent of engineering, H. R. Westcott, a far bigger job than was anticipated. The problem was not merely to make an extension to an old plant and to install the most efficient machinery, but was also that of converting an old station into a modern one without interruption of service and meanwhile providing for a rapidly growing business.

The old station, an exterior view of which is shown in Fig. 1, was a low one-story building of inflammable construction, containing few windows and by no means an ideal station. On the front were two rooms—one containing turbo-generators, switchboard, etc., the other formerly used for engines. The basement floors of both rooms were sometimes covered with tidewater. The boiler-room floor was only 2 ft. above high water, and the tide ebbed and flowed in the ashpits. On the west side the walls were on the harbor line, and on the north side they were on the street line. Fortunately, on the south and east sides there was room for future growth.

This station furnished electricity for New Haven and its suburbs, and as there was no other site available at tidewater, it was necessary that the new station be built on the site of the old one and without interruption of service.

Construction of the New Station

Although the old station was at tidewater, coal had been delivered by teams from a local coalyard. It will now be delivered by barges alongside a new wharf, unloaded by a locomotive crane, crushed and automatically delivered to a bunker over the boilers or to yard storage where it can be reclaimed by the locomotive crane. This improvement compelled dredging a considerable area of the river.

Before starting the new construction work it was necessary to remove the old engine room and blast out the foundations. No difficulty was encountered here except in constructing the condenser intake, which is 22 ft. below the surface. Steel sheet piling was used, and much trouble was caused by the soft, yielding nature of the soil.

It was necessary to pile the entire area, and exceptional difficulties were met in driving piles around the existing machinery, switchboard, boilers, etc., all of which were in operation. In some cases they were driven within 3 ft. of boilers that were steaming, and in one case they were driven only 4 ft. from a 2,300-volt switchboard. Here tubular metal piles in 6-ft. sections were driven by steam hammers, coupling the sections together as they were driven and afterward filling them with concrete. At the switchboard the exhaust steam from the hammers presented a problem that was successfully overcome by using flexible exhaust piping and electric fans.

A short description of the interior of the old turbine room is necessary before a real appreciation can be had of the difficulties encountered in building the new one. The old floor was of wood, and there was only 14 ft. between it and the lower chords of the old wooden roof trusses. Fig. 8 shows the outline of the old turbine room and a section through the new plant. The new roof is built at a modern height above the operating floor, and a switch and bus gallery has been built on one side.

On two sides the space requirements were exacting and it was necessary to build the new walls exactly where the old ones stood, namely, on the street line and on the harbor line. When doing this it was necessary to protect the switchboard and other machinery from the dirt incidental to construction work and also from inclement weather and fire. Furthermore, the foundations of the old building walls were not strong enough to support the new structure, and it was even necessary to build new foundations.

Rebuilding the Station Walls

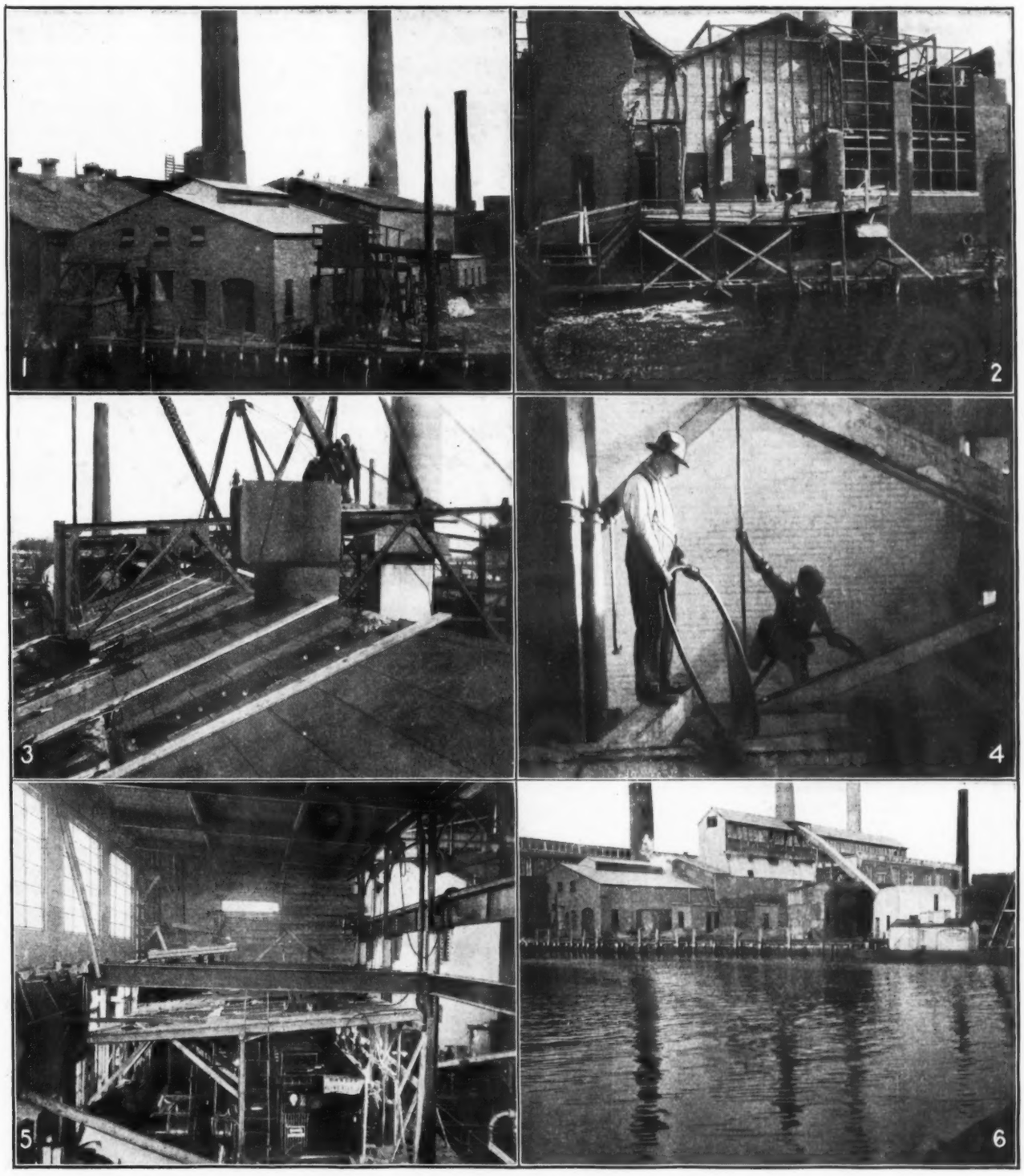
Temporary wooden walls were erected inside the old walls before removing them. These temporary wooden walls, which not only served as a protection to the machinery, but also supported the old roof, were both waterproofed and fireproofed and in many instances were in the closest proximity to high-tension electrical apparatus. Work on this part of the job was rushed, and in two weeks the front of the building was completed and part of the temporary wooden construction taken down. On the harbor side a small part of the old wall remains, and where the old brickwork did not harmonize with the new, sand-blasting and other treatments were resorted to until it is impossible to distinguish the old from the new work.

While the exterior walls were being completed the steel columns that support the new roofs were lowered into place through holes cut in the old roofs. In many places these columns were immediately in front of the switchboard and boilers and proper protection from the rain was of paramount importance.

As can be seen by referring to Fig. 8, the new turbine room roof trusses conflict with the old roof. It was therefore necessary to cut slots in the old roof just wide enough to permit placing the new trusses in position. The prevention of dirt falling on the generating units was of extreme importance and to accomplish this, canvas was first stretched beneath where each slot was to be made, the slot was then cut, inclosed and waterproofed. The trusses were then lowered into place. Fig. 2 shows the west end of the turbine room with the old wall nearly removed, temporary partition, old roof and the new wall started.

Erecting these columns and trusses was a delicate operation, particularly in front of the switchboard and also in the boiler room, where there was only one inch clearance between the columns and the front of the boilers that were steaming. Fig. 3 shows these slots and the roof trusses being lowered into position.

When the structural-steel frame of the turbine room was completed, the new roof was constructed and the building inclosed. From the exterior a new station had arisen, but inwardly it was the same old station except that it was more congested than ever. The next step was to remove the old roof over the turbine room. This was built with wood trusses, rafters and sheathing covered with tin. Here again the dangers from flying dirt had to be avoided and it was cleverly done. The old roof and rafters were carefully swept and the tin taken off. Next the vacuum cleaner was pressed into service, sucking up particles of dirt that had been years accumulating (Fig.



FIGS. 1 TO 6. PHOTOGRAPHS TAKEN DURING RECONSTRUCTION OF THE NEW HAVEN PLANT

Fig. 1—Exterior view of the old station. Fig. 2—West end of turbine room, showing old wall nearly removed. Temporary partition, old roof and new wall started. Fig. 3—Showing new trusses through old roof and holes for columns. Fig. 4—Cleaning old turbine-room roof. Fig. 5—Showing beams for switchboard gallery. Fig. 6—Power plant from the water front

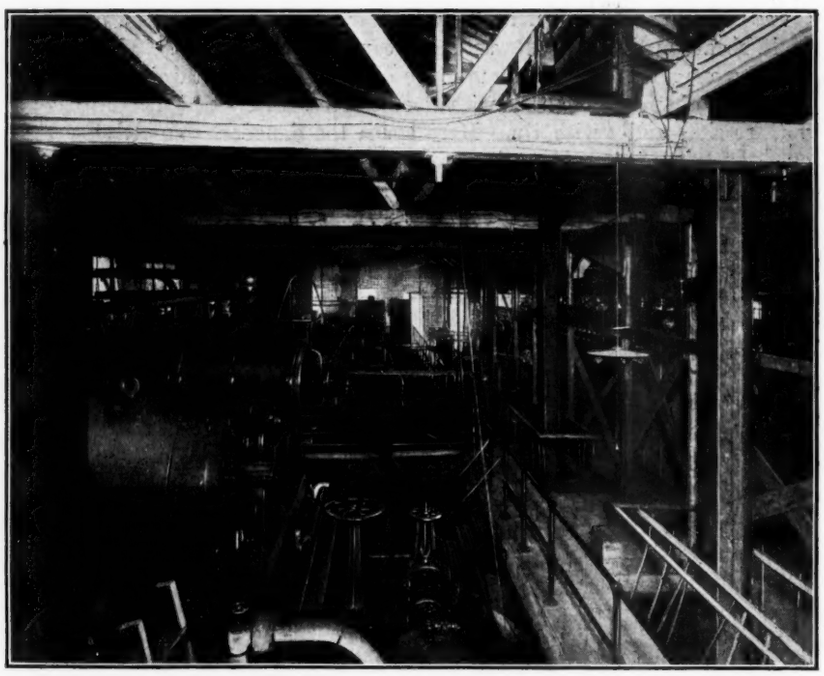


FIG. 7. INTERIOR OF THE OLD TURBINE ROOM

colors, which harmonize with the general color scheme.

Coal is delivered to the 700-ton overhead bunker by a belt conveyor of the shuttle type and from the bunker to the stokers by an automatic recording weigh larry, electrically operated. Stokers are used, with a separate drive for the stokers and blowers. Water-tube boilers and superheaters are used, each equipped with tube cleaners. A radial-brick chimney 160 ft. high with a varying taper carries away the products of combustion. This is said to be the most attractive chimney in New England. The inclined conveyor and a general view of the reconstructed plant are shown in Fig. 6.

Two 5,000-kv.-a. turbines were installed with surface condensers, engine-driven centrifugal circulating pumps, turbine-driven centrifugal hotwell pumps and reciprocating dry-vacuum pumps.

The remote control, hand-operated switching apparatus was superseded by electrically operated switches placed on a gallery above the old board, which

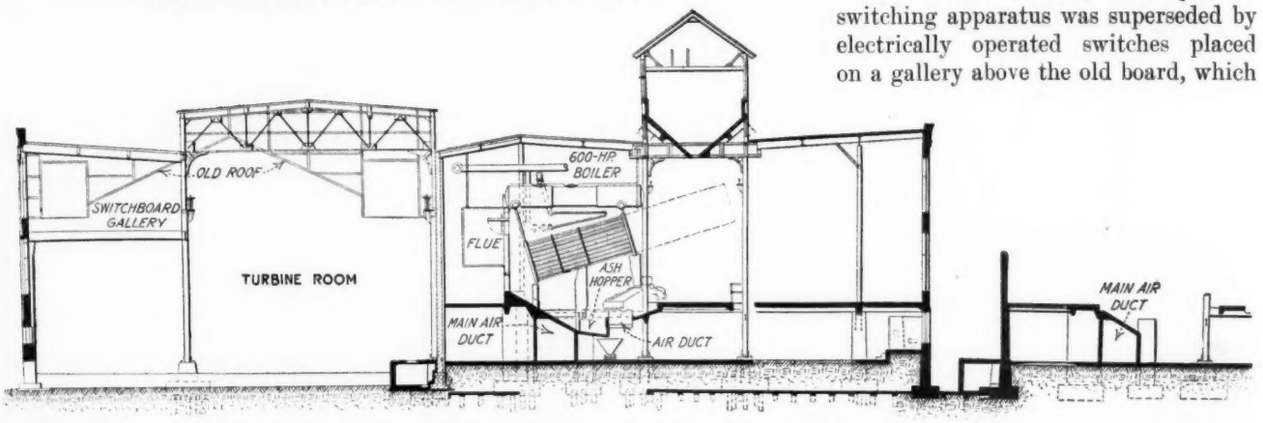


FIG. 8. SECTION THROUGH THE REMODELED POWER PLANT. THE PITCH OF THE OLD ROOF OVER THE TURBINE SHOWS THE ALTERATIONS

4). Not only dirt, but pieces of tin, splinters, nails and washers were gathered in, any of which might have, had it fallen, shut down the station or caused serious damage.

After the old roof had received this thorough cleaning it was sawed up and bit by bit taken apart. With the old roof down the old turbine room, Fig. 7, began to assume the appearance of a new station, Fig. 9. There was, however, much interior work to be done. Interior brick walls were removed and a switch and bus gallery, etc., were constructed over the old switchboard, Fig. 5. Meanwhile the boiler room was being constructed with a concrete coal bunker above the old boilers. The firing floor was raised 11 ft. and the boilers were set so that the ashes fall into concrete hoppers and are then taken away by a small railway car.

The interior is finished in an artistic manner, using soft gray tones and painting the structural steel similar

was then used as a control board. These electrically operated switches and also the disconnecting switches were placed in concrete compartments with the control circuits in conduits built into the walls.

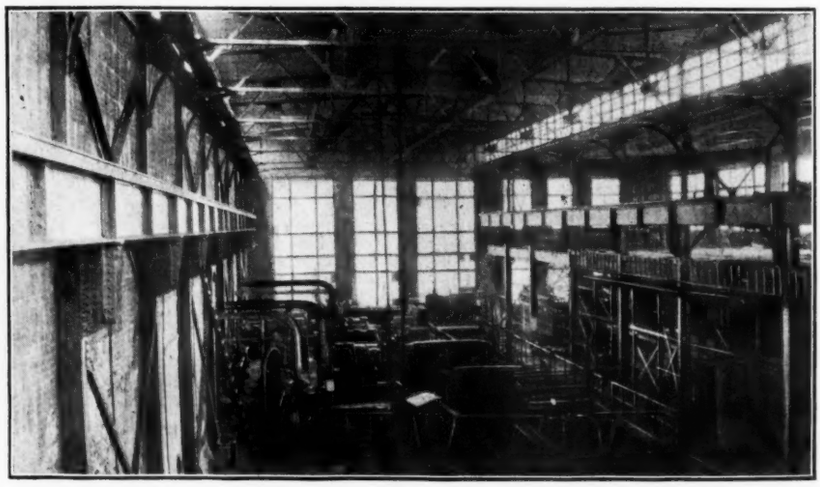


FIG. 9. INTERIOR VIEW OF THE REDESIGNED TURBINE ROOM

Viscosity and Its Relation to Lubricating Value

By Alan E. Flowers*

SYNOPSIS—The article describes what is meant by viscosity and the effect of that quality upon the "body" and lubricating value of an oil. The moving parts of a bearing are separated by a cushion of oil, the film adjacent to each surface sticking to that surface. The motion is thus between particles of the fluid, and the bearing obeys the laws of fluid friction. This gives the definitions that "fluid lubrication" is the separation of solid surfaces by means of a fluid of suitable viscosity and that "body" is this ability to be dragged between and so to lubricate surfaces. The resistances increase with the viscosity and the velocity, but decrease with increased clearance.

Practicing and operating engineers have in the past quite generally believed that viscosity was an abstract term related only to some obscure, scientific way of describing materials and having no relation to real lubricating value in everyday service. Even investigators were cautious about claiming any relation between viscosity, friction and power loss due to friction. Happily, this situation is gradually being changed, owing:

First, to a better analysis of the readings which have in the past been accepted as measuring viscosity; and second, to a clearer recognition of all the factors that affect the friction between two rubbing surfaces and a more exact measurement of these values.

It is not surprising that a relation between viscosity and friction could not be proved earlier, since we did not have, till quite recently, a correct knowledge of the real, or "absolute," viscosity of the lubricants, due to the errors of the flow-type viscosimeters in use, or a recognition and measurement of the effect of speed and clearance between bearing and journal, on the amount of friction. The labors of many different investigators have contributed to the solution of these difficulties, and a few of these are mentioned in the appended list of references. In the papers and in the discussion of the reports presented to the American Society for Testing Materials in 1914 and 1915, will be found additional information on viscosity.

Different Kinds of Friction

It is the purpose to present here the elementary, fundamental principles in the clearest and simplest way and in such fashion as will make the knowledge immediately useful. At the same time it is proposed to lay a correct foundation for any further study of the subject.

In order, therefore, to make perfectly clear what is meant by the term viscosity, let us consider for a moment the different kinds of resistance to motion.

There is first the resistance to the sliding of one solid body on another. Subject to slight modifications and variations, the general laws for friction of this kind are, that to keep up such a sliding motion: (1) The frictional force required is independent of the area of contact; (2) the frictional force is independent of the velocity (except that when starting, the force required to start the motion may be nearly double that required to continue it); (3) the frictional force increases directly as the total pressure between the rubbing surfaces.

These laws for the frictional force may be repeated in a much more convenient mathematical form as follows:

$$F = cP$$

where F is the force required for motion or is the frictional force, P is the total pressure between the rubbing surfaces, both of these quantities being expressed in the same units, and the "constant" c is the so-called friction coefficient.

Contrary to what might be expected and probably also to what is generally believed, well-lubricated bearings are not subject to these relations except when being started from rest or when under excessive loads, because when running the motion carries lubricant along, and forces it between the surfaces, actually separating them so that the journal runs on a liquid cushion. Naturally, then, the behavior of a bearing is governed by the laws of fluid motion. Only imperfectly lubricated bearings or those with rough surfaces or those where the journal is warped or bent allow metallic contact and follow to any extent the laws of friction between solids. Someone has said that "there are no laws for imperfectly lubricated surfaces." This is putting the case rather strongly, but it emphasizes strikingly the possible dangers and the probability of large and unexpected variations of friction, with consequent excessive heating.

Well-Lubricated Bearing Friction

The laws of fluid motion or of motion of a solid through a fluid must, then, be the ones to be considered in well-lubricated bearing friction, and it is necessary to form a clear idea of what we mean by a fluid as distinguished from a solid. One might say that the thing that distinguishes a fluid from a solid is its fluidity, meaning by this the ability of any part to move freely with regard to any other part. In other words, the parts of a fluid yield to the slightest forces and motion results, no matter how small the force may be, while a solid resists and no motion takes place till the force exceeds a certain fixed value. Small forces, less than the so-called elastic limit, may twist a solid, but when the force ceases the solid resumes its original shape. The only limitation to this fundamental distinction between solids and fluids is that some materials possess plasticity; that is, they resist small forces, particularly those suddenly applied, but yield under larger forces or under the continued application of even small forces. Beautiful examples of these plastic materials are asphalts, pitches and greases. These materials act as solids under small forces and as fluids under large forces or continuously applied forces.

*Professor of electrical engineering, Ohio State University.

It is a matter of common observation that some fluids flow more freely than others; that is, there is greater freedom for the motion of one part through the rest of the fluid. In the more exact terms of the engineer, a greater amount of motion results from the application of the same amount of force. The converse or reciprocal of this property of fluidity, which might be called the resistance to relative motion, is the property to which the name viscosity is given. Thus we have the paradox of defining fluids by their viscosity, or their *degree of lack of fluidity.* Internal friction is not a good substitute for the term viscosity, because it implies "rubbing," as of solids, and absence of motion till the force exceeds the value needed to tear the particles along.

It is plain that when the parts of a fluid move, there is this property of viscosity resisting motion, and we speak of this as the viscous resistance.

Viscous Resistance of a Fluid

It is quite natural to ask whether the viscous resistance that is due to the action of parts of the fluid on one another can account for all the resistance when a solid moves through a fluid or a fluid flows along a wall, as when a fluid flows through a pipe or a journal turns on its cushion of oil. This is a legitimate question and can be answered only by experiment.

There are two things to be looked for. The first is to determine whether there is any slippage, or relative motion between the solid wall and those particles of the fluid nearest the wall. Here the experimental answer is very positive and final. It is, that except in rare cases the particles of the fluid in actual contact with the walls adhere so strongly to the walls that there is no slippage or relative motion of the solid and this part of the fluid, so that the solid is surrounded by, and carries with it, a small portion of the fluid and consequently all the relative motion is between fluid and fluid and all the resistance is due to the laws of fluid motion. Even the fluids that do not stick to and wet the walls, as in the case of mercury and glass, behave in this way to such an extent that only a negligible fraction of the resistance can be due to slippage. For one particular case that was investigated, where the flow of mercury through small tubes was measured, not even one five-hundredth of the resistance could have been ascribed to friction between fluid and solid due to slippage of the fluid along the wall.

The second thing to be looked for is the effect of the inertia of the particles of the fluid when they are brought from standstill to some appreciable velocity or when hurled out of the way of a moving body or when the particles of the fluid are hurled hither and thither in eddies and turbulent motions in those cases where there is plenty of room in the vessel or between the walls of the tube or where there is a large clearance between the two bearing surfaces.

Why Tests Lack Consistency

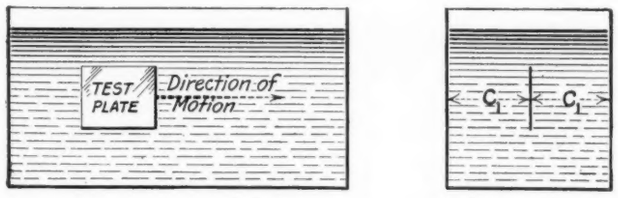
This has been the stumbling block that has destroyed much of the value of otherwise good work, for experiment answers that "it all depends." In other words, for high velocities, for rough walls, for large tubes, passages and clearances, for dense fluids and for materials of very low viscosity, a large part of the resistance to motion may be due to inertia resistances.

If, then, we keep the velocity low enough or use such shapes that the fluid is not hurled about in eddies, we may feel sure that all the resistance to motion is due to the lack of freedom of motion of one particle of the fluid on another; that is, to the property of viscosity of the fluid.

By observing that the slowing down of a body oscillating slowly to and fro when immersed in a fluid is the same at one depth of immersion as at another, it has been shown that viscous resistance is independent of the pressure on the fluid (except for enormous pressures).

It is evident that the amount of resistance would be greater for a large area and for higher relative velocities, and careful experiment has abundantly confirmed these relations. Just what is meant by relative velocity is made more clear by considering specific cases.

Suppose we had a long, deep, narrow vessel and put a thin plate parallel to and midway between the side walls, as in the accompanying sketch. It is evident from the foregoing that when the test plate is moved a film of fluid adheres to the plate and moves with it at some velocity, which we may designate as V_1, while a film



ILLUSTRATING EFFECT OF CLEARANCE

next the vessel walls adheres to them and so is stationary. Intermediate portions would move at some intermediate velocity. From this it would appear that the total velocity of fluid on fluid is equal to V_1, the velocity of the test plate, and that this velocity is distributed over the distance c_1, separating the test plate and wall so that the average relative velocity would be v_1/c_1. In a wider vessel, where the separation could be made twice as great, the same velocity V_1 would be distributed over $2c_1$, twice as great a distance, and the average relative velocity would be $V_1/2c_1$ or would be half as great as before. Under these conditions the test plate would evidently move more easily, and the greater ease of movement is directly the result of the lower relative velocity. For clearances small enough to make feasible the use of average velocities, the resistance to motion would vary directly with the relative velocity. These relations may be stated more concisely as follows:

$$R_v \text{ varies with } A\frac{V}{c}$$

where A is the surface area, V is the velocity, c is the clearance.

If a test were made with a plate of unit area or the resistance per unit area determined from a test for a case where the relative velocity was unity, a certain value for the resistance would result and the value of this unit of resistance would be characteristic of the fluid used—in particular a characteristic of the lack of fluidity of the fluid; and if the value of this unit resistance be designated by r, we have a means of calculating the resistance for any case by multiplying the resistance per unit area and per unit relative velocity by the total area and by the relative velocity.

Mathematically, we may write the expression for the viscous resistance as:

$$R_v = r A \left(\frac{V}{c}\right)$$

where

R_v = Viscous resisting force for any case;
r = "Viscosity" or the viscous resisting force per unit area and per unit relative velocity;
A = Surface area in motion;
$\left(\frac{V}{c}\right)$ = Relative velocity.

The general property of viscosity is, then, the lack of freedom of flow; and put more precisely in engineering terms, the viscosity is the resisting force per unit area per unit relative velocity.

When clearances are large and the actual velocity of the intermediate portions of the fluid cannot well be represented by the average relative velocity $\left(\frac{V}{c}\right)$, a better form of statement is to use the calculus form and write $\left(\frac{dv}{dc}\right)$ meaning by this the ratio of the difference of the velocities of two closely adjacent very thin sheets of the fluid to the difference of their positions (or their distance apart).

Why Present Viscosimeters Fail

The reason all the present flow-type viscosimeters give wrong results and so have made impossible a true correlation between viscosity and lubricating value is that they are standardized with water, which flows out so rapidly that about five-sixths of the resistance is due to inertia effects and eddies and only the small remainder is due to the viscosity. In these instruments, each of which consists of a vessel with a short, narrow outlet in the bottom, through which the fluid passes, the time required for a given quantity to pass out, determined by means of a stop-watch (the outflow time), is taken as a measure of the viscosity. When standardized with water, an instrument such as the Saybolt requires, say, 28.5 sec. for the outflow of water at 20 deg. C. or 68 deg. F. Some oil may require twice as long, or 57 sec., but such an oil would be really nearly ten times as viscous, instead of just twice. The time it ought to take for water to flow out would be about 5½ sec. if viscosity alone determined its flow. Another way of putting it is to state that if you could test a material of the same density as water so that the inertia effects would be the same, but having no viscosity at all, that is, infinite fluidity, the outflow time for such a material would not be zero, but would be almost exactly 27 sec.; that is, it would get out only 1½ sec. quicker than water.

Some years ago, Ubbelohde gave the form and the constants for calculating the absolute viscosity from the readings taken with the Engler viscosimeter. More recently Meissner (6) has compared the readings of the Engler, the Redwood and the Saybolt viscosimeters. These results are restated in the written discussion of the Report of Committee D2 on Standard Tests for Lubricants at the 1915 convention of the American Society for Testing Materials, along with additional expressions, so that the absolute viscosity may be calculated from the readings as well as the readings corresponding to any viscosity, provided the density is also measured, since these instruments give readings that depend on both the viscosity and density. The following symbols may be used:

E = Ratio of the outflow time to the water time. The water time is taken at 20 deg. C. or 68 deg. F.
t = Outflow time in seconds.
n = Absolute viscosity.
d = Density or specific gravity.

For the Engler viscosimeter, whose water time is 51.0 sec.,

$$\frac{n}{d} = 0.08019\,E - \frac{0.07013}{E}$$

$$\frac{n}{d} = 0.0015723\,t - \frac{3.576}{t}$$

$$t = 318.0\left(\frac{n}{d}\right)\left(1 + \sqrt{1 + \frac{0.0225}{\left(\frac{n}{d}\right)^2}}\right)$$

For the Redwood viscosimeter No. 1,263, which was tested and found to have a water time of 26.47 sec.,

$$\frac{n}{d} = 0.002631\,t - \frac{1.5770}{t}$$

$$t = 190.0\left(\frac{n}{d}\right)\left(1 + \sqrt{1 + \frac{0.01660}{\left(\frac{n}{d}\right)^2}}\right)$$

For the Saybolt viscosimeter No. 752, which was tested and found to have a water time of 28.57 sec.

$$\frac{n}{d} = 0.0021863\,t - \frac{1.4968}{t}$$

$$t = 228.7\left(\frac{n}{d}\right)\left(1 + \sqrt{1 + \frac{0.01309}{\left(\frac{n}{d}\right)^2}}\right)$$

As shown by these expressions for the calculation of the absolute viscosity, the values for the materials that are at all low in viscosity, such as water, are given by the differences of two relatively large quantities, so that the error of the determination is greatly increased. The errors due to inertia effects and eddies cease more or less abruptly, an effect not taken account of in these equations, and so for some readings the error in the final result will differ from that given by these equations.

The situation would not be so bad if all the oils tested were very thick or viscous and if they did not decrease in viscosity so greatly when warmed to the high temperatures to which they are subjected in service.

An Important Demonstration

In spite of this handicap, Ubbelohde (7), after compiling and comparing the results of former investigations, has shown that oils from different crude-oil fields and prepared by different methods of refining but having the same absolute viscosity give the same friction coefficient under similar test conditions.

If Ubbelohde's conclusion is substantiated, a very great advance will have been scored and it will be possible to duplicate any friction result by duplicating the viscosity of the lubricant.

It is very plain, too, that as long as it is possible to keep a continuous sheet of lubricant between the bearing

surfaces and to keep the same separation of the stationary and moving parts, the lower the viscosity the lower the friction loss.

The consideration that sets a lower limit to the viscosity and therefore to the friction-force coefficient is the speed and the load pressure on the bearing. The moving part carries the viscous lubricant along with it to the surfaces to be separated (provided no sharp edges are allowed to scrape the lubricant off). Anyone who has stuck his finger into thick molasses and pulled out half a cupful clinging to his finger will appreciate that it is its high viscosity, or lack of freedom of flow, that allows him to pull out so much molasses, while he would be able to bring out only a very small amount of water in the same way on account of the low viscosity of water and the ease with which all but the film wetting the finger would flow off the finger as it was withdrawn. Just so, the viscosity of a lubricant helps in lubrication by getting the lubricant to the place where it is most needed. It is this property of viscous materials that allows them to get between surfaces to which the name "body" has been applied.

Hersey (3) has stated that the carrying power of a bearing increases directly with increase of viscosity and also increases with increase of speed, but reaches a limiting value, so that further increase of speed causes no increase of carrying capacity.

Summary of Results

We might summarize these results by saying that since the lubricant adheres to the walls, the relative movement occurs between the different parts of the lubricant and the resistance obeys the laws of the resistance of fluid motion.

With smooth, narrow passages, or low velocities, so that turbulence is avoided, the principal part of the resistance is due to the lack of fluidity; that is, to the viscosity of the lubricant.

The viscous resistance for different cases increases with the viscosity and the relative velocity; that is, it increases with the total velocity, but decreases with increased clearance.

In general, the lower the viscosity the lower the friction, but since the stationary and moving surfaces should have as much lubricant between them as possible and since a thin film of the lubricant always adheres to the walls, it is necessary to have sufficient viscosity for the film attached to the moving part to drag along enough more lubricant to properly separate (that is, "lubricate") the surfaces, and the "body" of a lubricant is its ability to be dragged between surfaces.

Since a higher speed would carry along the lubricant better, it is possible to get satisfactory lubrication at high speeds with low-viscosity materials. This explains the need for low-viscosity lubricants for high speeds and high-viscosity lubricants for low speeds.

When the pressure between the parts is low, it is easy to get and keep lubricants between the surfaces and low-viscosity lubricants may be used, but if the pressure is high, tending to squeeze out the lubricant, high-viscosity lubricants must be used.

References—(1) Petroff, "Baumaterialkunde," Vol. 4., p. 269, 1899. (2) Sommerfeld, "Physikalische Zeitschrift," Vol. 4, p. 779, 1903. (3) Hersey, "Journal of the Washington Academy of Sciences," Vol. 4, No. 19, Nov. 19, 1914; "Journal of the American Society of Mechanical Engineers," September, 1915, Vol. 37, p. 534. (4) Ubbelohde, "Chemiker Zeitung," 1907, Vol. 31, p. 38. (5) Grüneisen. "Wissenschaftliche Abhandlungen der Physikalisch-Technischen Reichsanstalt," Vol. 4, No. 2, p. 154, 1904. (6) Meissner, "Chemische Revue," Vol. 12, p. 30, 1912. (7) Ubbelohde, "Petroleum," Vol. 7, p. 773, 1912. (8) American Society for Testing Materials, Technical Papers and Reports, 1914 and 1915.

Panama-Pacific Exposition--XI

The exhibit by the Lunkenheimer Co., Fig. 1, consisted of an unusually complete and comprehensive collection of valves, injectors, oilers, lubricators and boiler fittings. Iron-body puddled semi-steel and cast-steel gate valves in sizes up to 24 in. and brass-body gate valves up to 8 in., globe and angle valves of the same materials up to 12 in. of steel and iron and up to 4 in. made of brass were shown.

Nonreturn safety boiler-stop valves up to 10 in. attracted more than passing attention, as the importance of this type of valve is being more and more recognized by boiler users, as insurance against fatalities and also excessive damage which might occur before hand-operated valves could be reached and closed. The line of lubricators, oilers and grease cups was unusually elaborate and complete, suggesting an infinite variety of combinations possible from stock material.

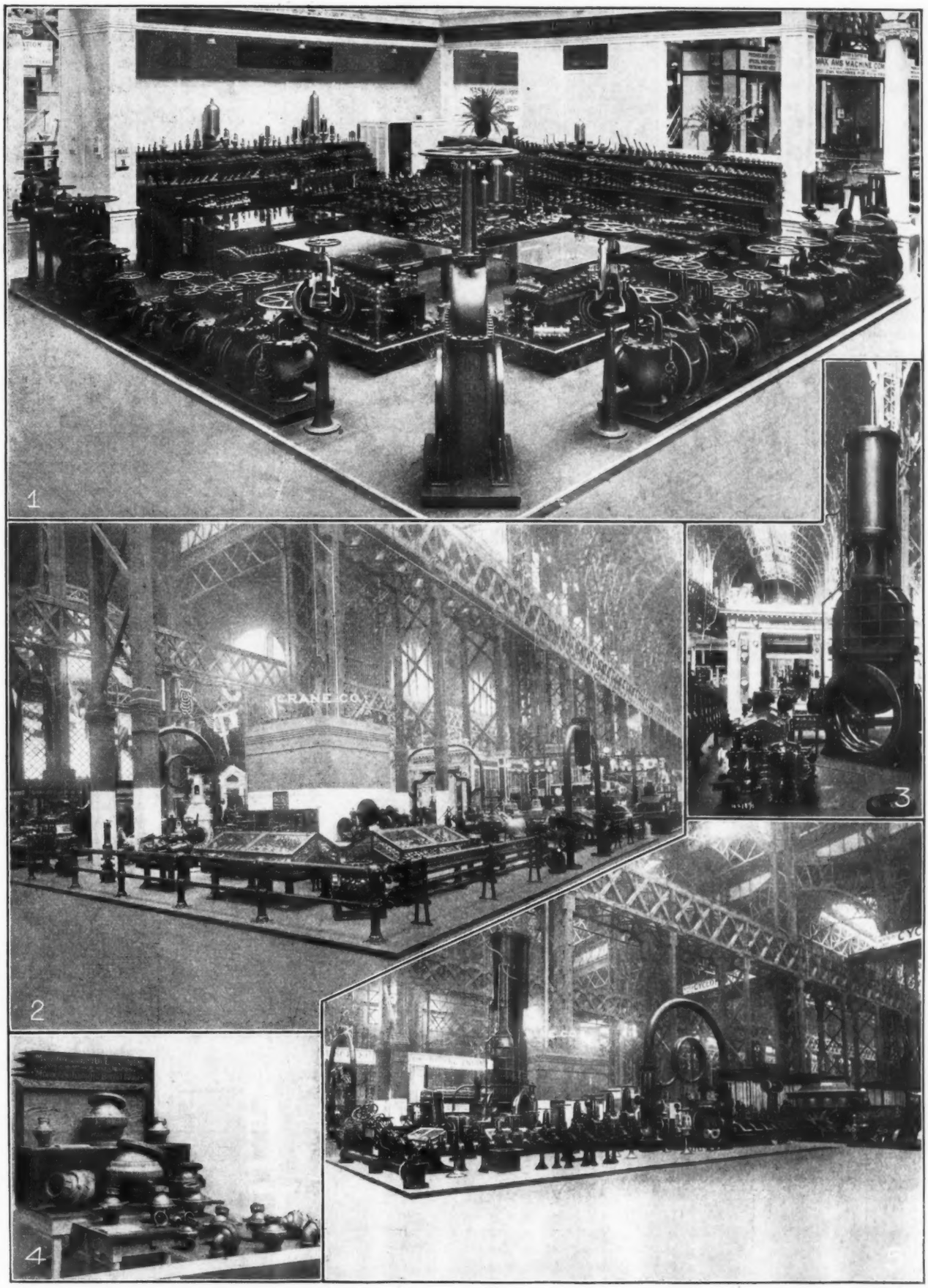
The space was skillfully laid out and arranged in an artistic manner, so that all items from the smallest to the largest were given appropriate settings. That the general use of motor vehicles has contributed largely to the public interest in exhibits of this nature is indicated by the attention given by the nontechnical public of the present as compared with that of other expositions.

The first object to attract attention on approaching the exhibit of the Crane Co., along Avenue E, was the 72-in. cylinder-operated gate valve, Fig. 3, that weighed approximately 57,000 lb. (over 28 tons), measuring when open 32 ft. 10 in. from the bottom of the valve to the top of the stem, the operating cylinder being 44-in. bore.

Valves of this type are used in connection with city water-supply systems and are made at the Bridgeport works of the Crane Co. In contrast with this a ⅛-in. valve weighing only 2 oz. was displayed, representing the extremes in sizes manufactured. Intermediate sizes of valves of all kinds, for steam, water, gas, ammonia, etc., were on display, or at least representatives of all types were to be found. A 48-in. back-pressure valve was also much in evidence. The vast profusion of other valves for all purposes formed probably the most elaborate and complete collection ever exhibited by any manufacturer anywhere.

Fittings of all kinds and for all purposes in a wide range of sizes formed an interesting collection even to the casual observer, while pipe bends and special shapes were formed into groups and shapes, with arches for entranceways to the "Crane block." The prominent position given to pipe bends was in keeping with their importance in modern power-plant piping.

Fittings as well as valves, shown in section cut at various angles and places, showed the interior construction and the remarkable uniformity in design and thickness of the metal. Of exceptional educational value also was the working exhibit of Crane-tilt steam traps. These



SOME OF THE VALVE AND FITTING EXHIBITS AT THE PANAMA-PACIFIC EXPOSITION

1—The Lunkenheimer exhibit. 2 and 5—Two views of the Crane Co.'s exhibit. 3—A 72-in. hydraulically operated gate valve. 4—Moran flexible joints

traps, when carefully adjusted, deliver a uniform quantity of water at each stroke, and when equipped with a tally or counter, they may be relied on as meters for the water fed through them.

Ammonia valves and fittings, although they do not enter into the work of every engineer, are always given a full share of the attention of the visitor, and the refrigeration man found a satisfactory display within the bounds of the "Crane block." The water-service and drainage specialties were displayed, and drainage fittings or special sanitary threaded fittings for sewer and drainage work were given considerable space. Figs. 2 and 5 are reproductions of photographs of this exhibit from different viewpoints.

Fig. 4 shows a part of the exhibit of the Moran flexible joints made on the ball-and-socket principle so that pipes at almost any angle may be joined, and by reason of their true spherical shape they will allow considerable motion, expansion and contraction, and still remain steam-tight. They are made in a variety of sizes for all commercial purposes.

Charts for Estimating the Strength of Bolts

By William F. Fisher

Charts Nos. 1 and 2 were prepared for use in determining the stresses on and strength of threaded bolts of standard type, as used in the United States. Having found them useful and convenient in practice, I am submitting them for the benefit of others. Chart No. 1 is for bolts ¼ to ¾ and No. 2 for bolts ¾ to 2½ in.

The following formulas were used in preparing the charts:

$$L = A \times f \qquad A = \frac{L}{f} \qquad f = \frac{L}{A}$$

where

L = Load on bolt, in pounds in tension;
A = Area of bolt at root of thread, in square inches;
f = Unit fiber stress on bolt material at root of thread, in lb. per sq.in.

Method of Using Charts

Example No. 1: What will be the unit tensile stress in lb. per sq.in. on a ⅝-in. bolt when supporting a load of 4200 lb. in tension?

Solution: At the bottom of Chart No. 1 find the load on the bolt in pounds (in this case 4200), follow the dotted line upward in the direction of the arrows until it intersects the horizontal line for a ⅝-in. bolt. As the point of intersection lies approximately halfway between the two diagonal lines representing a unit tensile stress of 20,000 and 22,000 lb. per sq.in. respectively, the unit tensile stress on the threaded part of the bolt will be approximately 21,000 lb. per sq.in.

Example No. 2: It is desired that the stress on the bolt in the above example should not exceed 15,000 lb. per sq.in. as a maximum. In this case, what size of bolt should be used?

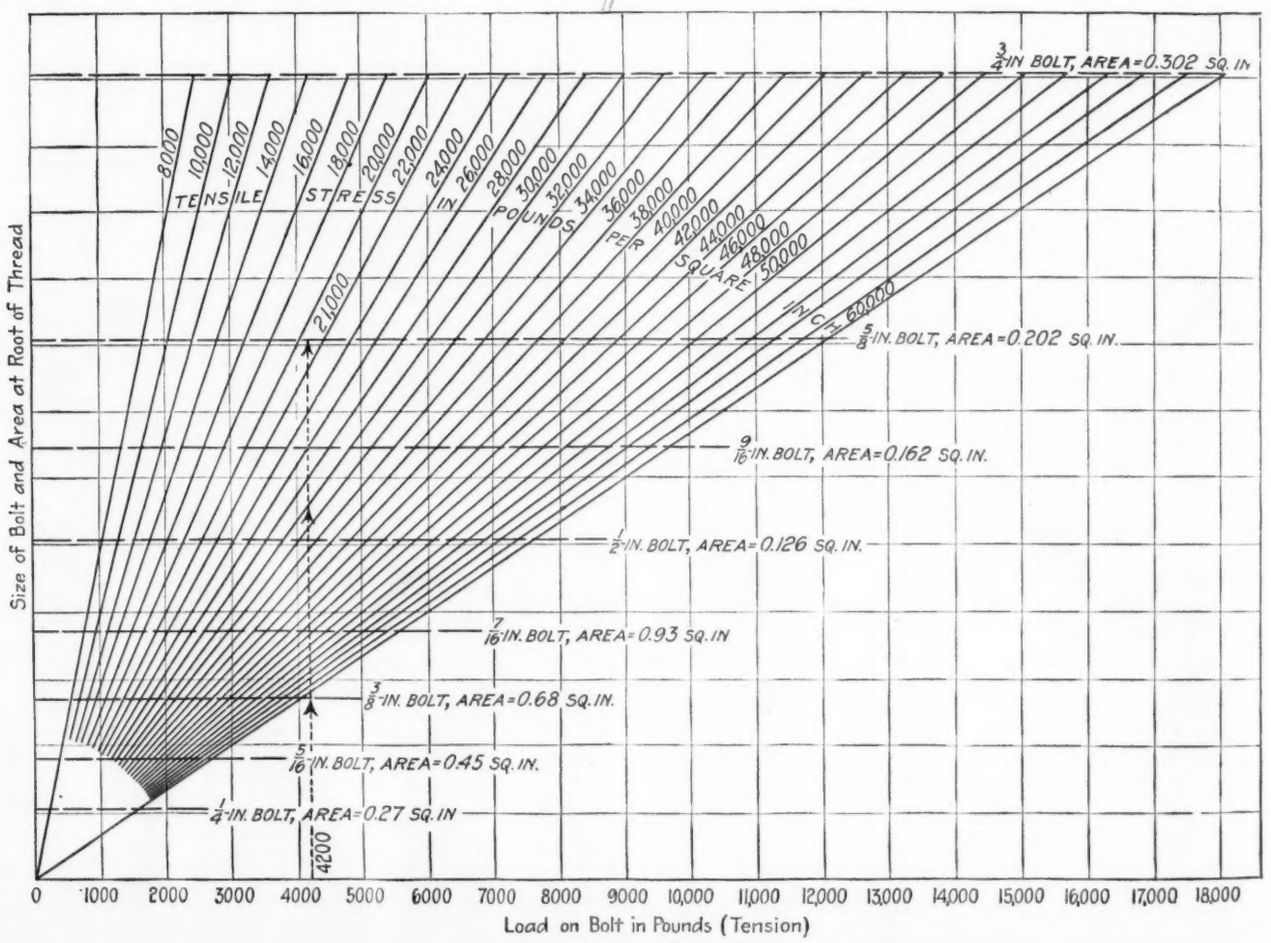


CHART NO. 1 FOR STRENGTH OF BOLTS ¼ TO ¾ IN. DIAMETER

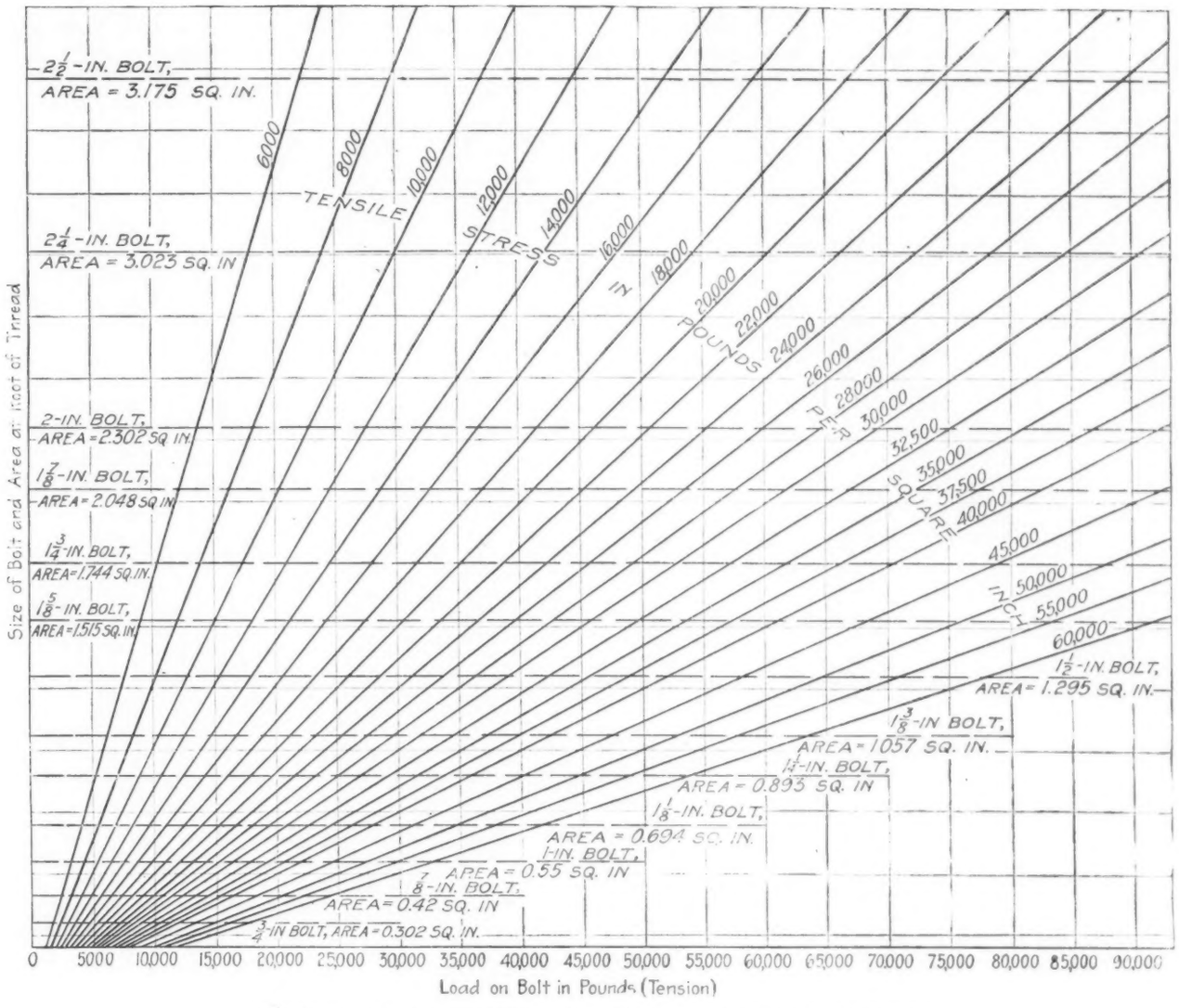

2½-IN. BOLT, AREA = 3.175 SQ. IN.
2¼-IN. BOLT, AREA = 3.023 SQ. IN
2-IN. BOLT, AREA = 2.302 SQ. IN.
1⅞-IN. BOLT, AREA = 2.048 SQ. IN.
1¾-IN. BOLT, AREA = 1.744 SQ. IN.
1⅝-IN. BOLT, AREA = 1.515 SQ. IN.
1½-IN. BOLT, AREA = 1.295 SQ. IN.
1⅜-IN BOLT, AREA = 1.057 SQ. IN.
1¼-IN. BOLT, AREA = 0.893 SQ. IN
1⅛-IN. BOLT, AREA = 0.694 SQ. IN.
1-IN. BOLT, AREA = 0.55 SQ. IN
⅞-IN. BOLT, AREA = 0.42 SQ. IN
¾-IN BOLT, AREA = 0.302 SQ. IN.
6000
8000
10000
12000
14000
16000
18000
20000
22000
24000
26000
28000
30000
32,500
35000
37,500
40000
45000
50,000
55,000
60,000
TENSILE STRESS IN POUNDS SQUARE INCH
Size of Bolt and Area at Root of Thread
0 5000 10,000 15,000 20,000 25,000 30,000 35,000 40,000 45,000 50,000 55,000 60,000 65,000 70,000 75,000 80,000 85,000 90,000
Load on Bolt in Pounds (Tension)

CHART NO. 2 FOR STRENGTH OF BOLTS ¾ TO 2½ IN. DIAMETER

Solution: Follow the 4200-lb. vertical line to the ¾-in. horizontal bolt line where the two lines intersect with the diagonal line representing a unit tensile stress of 14,000 lb. per sq.in. Therefore, a ¾-in. bolt should be used.

By following the 4200-lb. line in the direction of the arrows we find at the points of intersection that a ⅜-in. bolt would be stressed considerably over 60,000 lb. per sq.in., a $\frac{7}{16}$-in. bolt approximately 46,000 lb. per sq.in., a ½-in. bolt approximately 33,500 lb. per sq.in., and a $\frac{9}{16}$-in. bolt approximately 26,000 lb. per sq.in. In a similar manner, knowing the load a bolt is to carry, the unit tensile stress can be readily determined for any-sized bolt, and knowing what safe unit fiber stress to allow on the bolt material, it is a simple matter to determine the size of bolt to use for the given conditions.

Example No. 3: What load will a 2-in. wrought-iron bolt support, in tension, the unit fiber stress on the material of the bolt not to exceed 10,000 lb. per sq.in.?

Solution: On Chart No. 2, follow the horizontal 2-in. bolt line to the right until it intersects the diagonal line representing 10,000 lb. fiber stress. At the point of intersection follow downward to the bottom of the table and read 23,000 lb.—the maximum safe load to allow on the bolt.

Example No. 4: Assuming the ultimate tensile stress of the bolt material to be 50,000 lb. per sq.in., what load in tension will be required to rupture a 1⅜-in. bolt through the threaded part?

Solution: Follow the 1⅜-in. horizontal bolt line to the right until it intersects the 50,000-lb. diagonal line. At the point of intersection follow downward and read 53,000 lb., the load required to break the bolt.

The probable breaking load on wrought-iron bolts will average from 45,000 lb. per sq.in. on bolts up to ¾ in. in diameter to 50,000 lb. per sq.in. in the larger sizes, whereas the probable breaking load on mild-steel bolts will average from 50,000 lb. per sq.in. on bolts up to ¾ in. in diameter to 60,000 lb. per sq.in. on the larger sizes. In order to determine the safe allowable unit fiber stress, a factor of safety of from four to six should be allowed, depending upon the service for which the bolt is intended.

Greases Are Used for Extra-Heavy Work, although some of the so-called hard oils are but little more viscous when heated to running temperature than heavy oil. Generally speaking, it may be almost any kind of mineral oil mixed with soap until it is of the desired solidity. Various other substances have been incorporated in such grease, such as graphite, sulphur and the like for special work, giving good results.

Parallel Operation Troubles

By H. E. Ford

SYNOPSIS—Means by which the tendency for a turbo-generator to take all the load from the reciprocating engines was overcome.

About a year ago a 200-kw. three-wire direct-connected turbine-driven generator was installed in a power plant that already had two high-speed engine-driven units, one of 150 kw. capacity and the other 75 kw. The engine-driven generators were compound wound, but did not have interpole windings. When an attempt was made to operate all the units in parallel, trouble was encountered, as the turbine would take all the load and trip all the breakers. As it was necessary to run them in parallel at once, they were started and paralleled by giving the engine-generator rheostats a quick turn just as the turbo-generator switch was closed. This boosted their voltage so that the load was shared proportionally, but was a rather nerve-trying performance. As the fields heated up, the resistance would be all cut out of the rheostats of the engine units and they would gradually take less and less load, and the turbine unit would be overloaded.

The manufacturer was appealed to and sent a troubleman, who proceeded to shunt the series fields of the turbo-generator, but the results were no better. Several more men were sent, each one adding shunts until the switchboard was full of shunts. The trouble still continuing, another man came and disconnected all the shunts and put extra resistances in series with the rheostat, so that the voltage could be lowered to make the units share their loads better. This of course did not remedy the trouble, and it was not desirable to lower the voltage.

The experiments cited had cost considerable time and money and had exhausted the customer's patience without

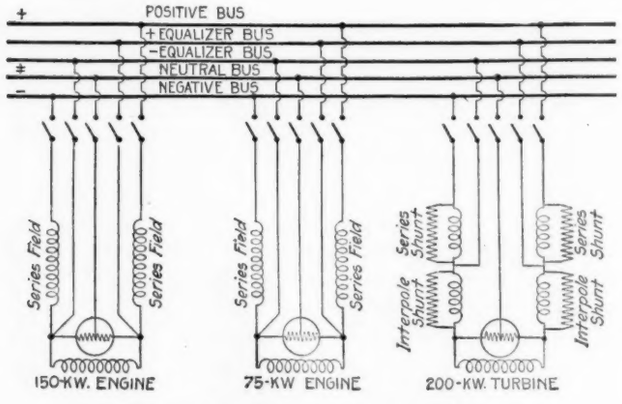
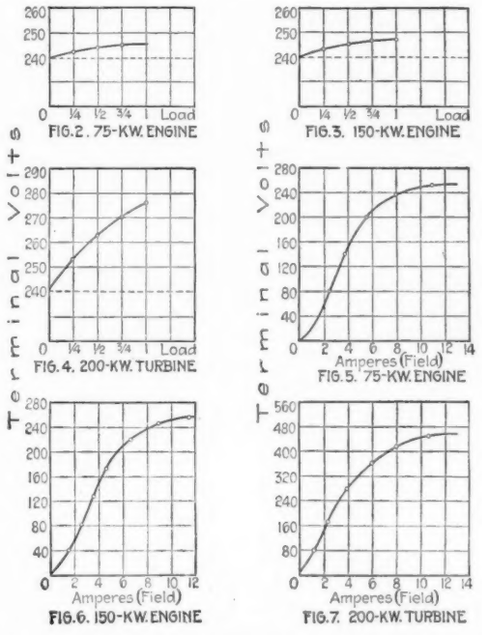


FIG. 1. ORIGINAL FIELD CONNECTIONS

having bettered conditions. Shortly after this the turbo-generator took all the load and, on account of its higher voltage, motored the engine unit running in parallel with it, the reverse-current relay having failed to operate. The engine speeded up, and one of the links on the inertia governor flew out. The engine probably would have been wrecked had not the engineer acted promptly in shutting off the steam and opening the switch. About this time the writer was called into the case.

The first thing done was to check the wiring to see if the connections, especially the series-field and equalizer connections, were all right. They were found correct and as indicated in Fig. 1. It was then noted that all the resistance was cut out of the engine-generator fields and most all cut into the turbo-generator fields. Speed readings were then taken, and it was found that the engines were running slow and the turbine just right.



FIGS. 2 TO 7. COMPOUNDING AND SATURATION CHARACTERISTICS

Owing to the conditions there was no chance to make proper tests with a water-rheostat load, and any changes made had to be guaranteed beforehand, as no delays or stops could be tolerated. Therefore data were obtained in the following way: A unit was cut in light, then the rheostats on the other units regulated to gradually increase the load on the unit under observation. Readings were taken of the speed, voltage and current, so that a compounding curve could be plotted. The resulting characteristics were as shown in Figs. 2, 3 and 4. Saturation characteristics were taken at night while the fields were hot, the voltage, speed and field current being read for these. These saturation curves are shown in Figs. 5, 6 and 7.

Examination of these curves shows: First, that the turbo-generator was overcompounded nearly eight times as much as the engine generators; second, the two latter were working on nearly a fully saturated field, whereas the turbo-generator was working very much below saturation. The series fields of the engine-driven generators therefore would not have the same effect per ampere-turn as would those on the turbo-generator.

These data show very clearly what was necessary to correct the trouble. Referring to Fig. 1, it is seen that

there were no shunts on the series fields of the engine units. Fig. 8, which is a simplified diagram of the two generators in parallel, makes it evident that the negative line and equalizer connects the two series fields in parallel. Therefore shunting one field means simply putting in a third parallel resistance. This shows that a shunt on one field also shunts the other fields and not only just the one shunted, as is often supposed. Therefore, when the troublemen placed additional shunts on

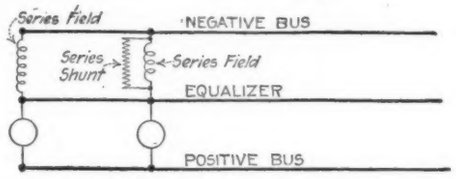


FIG. 8. SHOWING HOW A SERIES SHUNT AFFECTS BOTH MACHINES

the turbo-generator fields, they were not changing the relative characteristics in any way, so did not get results.

To remedy the trouble it was proposed by the writer to increase the engine speed, decrease the turbine speed and increase the resistance of the series-field circuit of the turbo-generator.

Increasing the speed of the engine units would lower the saturation of their generator fields and decrease the field current. This was desirable, as the fields were running so hot they could hardly be touched. Also, this change would give the engines more power and greater flywheel storage of energy, which was greatly needed. This change, aside from helping parallel operation, would seem desirable, but it was found impossible to increase the speed, as the governor would be operating in such a position that one of the links would be unstable and likely to slip out.

Therefore the speed of the turbine was lowered about 4 per cent. and the series-field windings were shunted.

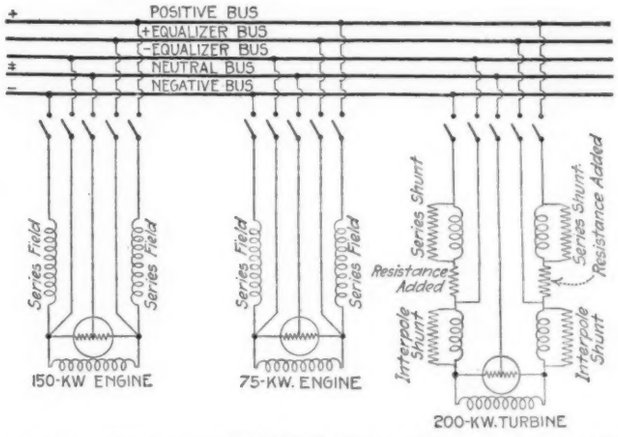


FIG. 9. FINAL FIELD CONNECTIONS WITH RESISTANCE ADDED TO SERIES FIELD

After estimating the resistance of the series field, a german silver resistance of about 0.008 ohm was inserted in the series circuit in each side of the line. The results were satisfactory, and the units paralleled nicely with hardly any trouble. However, it was found that these resistances did not have sufficient capacity; so new ones were made up with about 2½ times the cross-section and 15 per cent. more resistance. Parallel operation was perfect after this change. The final connections were as shown in Fig. 9.

"Insuluminum" Soot-Blower Caps

Some time ago announcement was made from the General Electric Company's laboratory that a process called "calorizing," for the protection of metal subjected to high temperatures, had been perfected. It has the effect of producing an aluminum alloy upon the surface of the metal to be protected. The Diamond Power Specialty Co., Detroit, Mich., now owns and controls the exclusive rights to the use of this process for the treatment of soot-blower units.

The numerous tests that have been made indicate that metal treated by this process has the ability to successfully withstand exposure to combustion gases without deterioration, at a temperature from 800 to 1,700 deg. greater than the uncalorized metal can withstand. For instance, an experiment was made with two tube-blower caps, one treated, the other (untreated) of extra-heavy wrought iron. The temperature in the furnace was about 2,500 deg. F. When the untreated cap began to melt both were withdrawn and plunged into cold water. An examination showed that the treated cap was apparently in as good condition as before it was exposed to the flames. Soot-blower units are not exposed directly to the fire, neither does the temperature of the gases of combustion ever reach 2,500 deg. where they are used, but this test shows to what a marked degree the melting point of a metal is increased by the calorizing process.

A somewhat similar test was made, using two pieces of pipe. It was originally planned to expose these two pieces to combustion gases for a long period. At the end of eight hours the test was concluded because the uncalorized pipe was so badly deteriorated. More than this, the piece of treated pipe had previously been used in other experiments, during which it had been alternately heated to 1,000 deg. C. for about 50 hr. and cooled in an electric resistance furnace open to the air. Another rather extreme test has been applied to this same pipe. It was heated to 900 deg. C. and plunged into cold water after it had cooled to a dull-red. This was repeated three times, and the surface showed no signs of cracks or of any tendency to scale.

In another test, two pieces of pipe, one treated, the other extra-heavy wrought-iron pipe, were run side by side in a furnace at 1,500 deg. F. in an atmosphere of sulphur dioxide for four hours. At the end of this time the ordinary pipe was so affected by this deleterious atmosphere that the experiment had to be discontinued. The treated pipe was in practically as good condition as before the experiment, making it evident that SO_2 gas has no effect on "Insuluminum."

Trial installations of "Insuluminum" units have been made in all types of water-tube boilers, placing them in the passes where the temperature reached 1,800 deg. F., and they met the conditions without indicating any sign of disintegration from long exposure to the deleterious effect of combustion gases at that temperature.

Illinois Coal Production—Illinois markets absorb about one-half of the output of its coal mines, Chicago alone demanding 14 per cent. of the state's production. The railroads of the state consume 18 per cent. Practically no Illinois coal moves eastward; to the west, it dominates the markets of Missouri and Iowa almost to the eastern margin of their own coal fields. The coal goes in large quantities into southwestern Wisconsin, southern Minnesota and eastern South Dakota.

Graphical Determination of Thermal Value of Coal

By W. C. Stripe

SYNOPSIS—A chart based on a modification of Dulong's formula for readily ascertaining the heat value of a coal when the ultimate analysis is known.

The thermal value of a certain coal may be determined either by burning a sample in a calorimeter or by calculation from a chemical analysis. When accuracy is desired, the first method should be used, as it is definitely known that coals having practically the same ultimate analyses show a difference in thermal value when burned in a calorimeter. This difference is due to the manner in which the elementary constituents of the fuel are combined and cannot be determined by chemical analysis.

The formula commonly used for computing the heat value from the ultimate analysis is credited to Dulong. The original formula has been modified to suit special applications, and the accepted form most applicable to coal is

$$B.t.u.\ per\ pound\ of\ dry\ coal = 14{,}600\ C + 62{,}000\left(H - \frac{O}{8}\right) + 4{,}000\ S$$

in which C, H, O and S are the proportionate parts by weight of carbon, hydrogen, oxygen and sulphur. It is customary to determine ultimate analyses on the dry-coal basis, and this formula is correct only with reference to analyses so determined. If an analysis has been determined on the moist-coal basis, it must be converted to the dry-coal basis by dividing the percentage of each of the elementary constituents by 1 minus the percentage of moisture before using the formula.

The thermal values obtained by calculation are only approximate, and equally satisfactory results may be obtained more readily by use of a graphic representation of the formula shown by Fig. 1. Assume a coal having the following ultimate analysis: Carbon, 79.90 per cent.; hydrogen, 4.98; oxygen, 4.31; nitrogen, 1.85; sulphur, 1.13; ash, 7.83; moisture, 2.91 per cent.

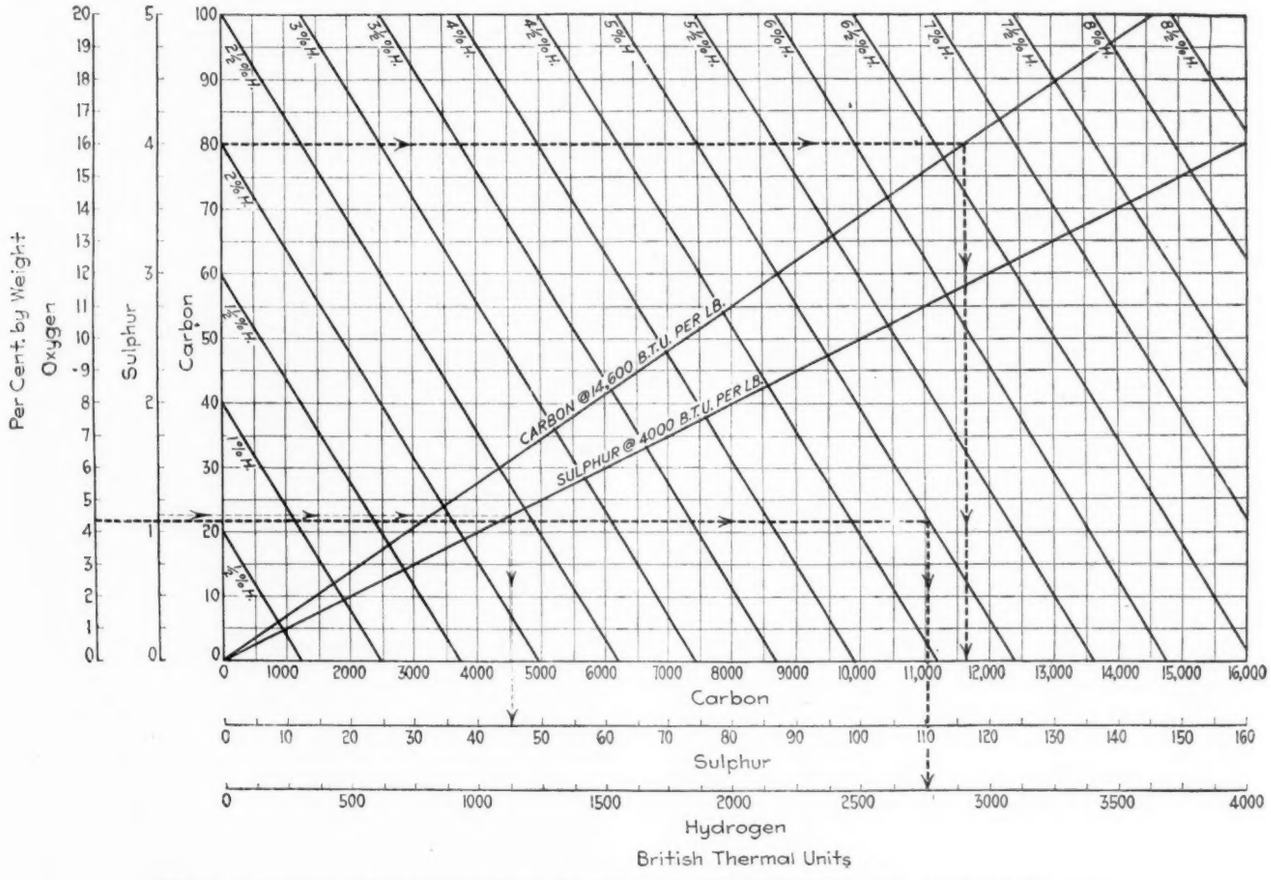


FIG. 1. GRAPHIC REPRESENTATION OF DULONG'S FORMULA FOR HEAT VALUE OF COAL

Referring to Fig. 1, the upper arrowed line shows that the carbon represents approximately 11,660 B.t.u. The lower heavy dotted line shows that approximately 2,750 B.t.u. must be added for the 4.98 per cent. hydrogen, when 4.31 per cent. oxygen is present. The light dotted line shows that approximately 45 B.t.u. will be obtained from the 1.13 per cent. sulphur. The summation of these three values gives 14,455 B.t.u. as the total approximate thermal value of this fuel. Calorimeter tests on coal of the foregoing analysis have shown a value of 14,380 B.t.u., hence the results obtained graphically are satisfactory.

The thermal values of fuel, determined from proximate analyses, are not usually to be depended upon, and the results so obtained are seldom sufficiently accurate to be of value. It is apparent, however, that a general relation exists between the percentage of fixed carbon in the combustible and the thermal value of the combustible. The curve shown by Fig. 2 represents this relation and was plotted from 66 analyses made by the United States Geological Society, of coal from 18 different states. Assume a coal having the following approximate analysis, determined on a dry basis: Fixed carbon, 57.5 per cent.; volatile combustible, 35.0; ash, 7.5; moisture, 4.5 per cent. In Fig. 2 the heavy arrowed line indicates that the fixed carbon is 62 per cent. of the total combustible. The light arrowed line indicates that with the fixed carbon and volatile combustible so proportioned, a thermal value of approximately 14,950 B.t.u. per pound of combustible may be expected. Then, if 92.5 per cent. of the fuel is combustible, the thermal value per pound of dry fuel is 14,950 times 92.5 per cent., which figures approximately 13,828 B.t.u.

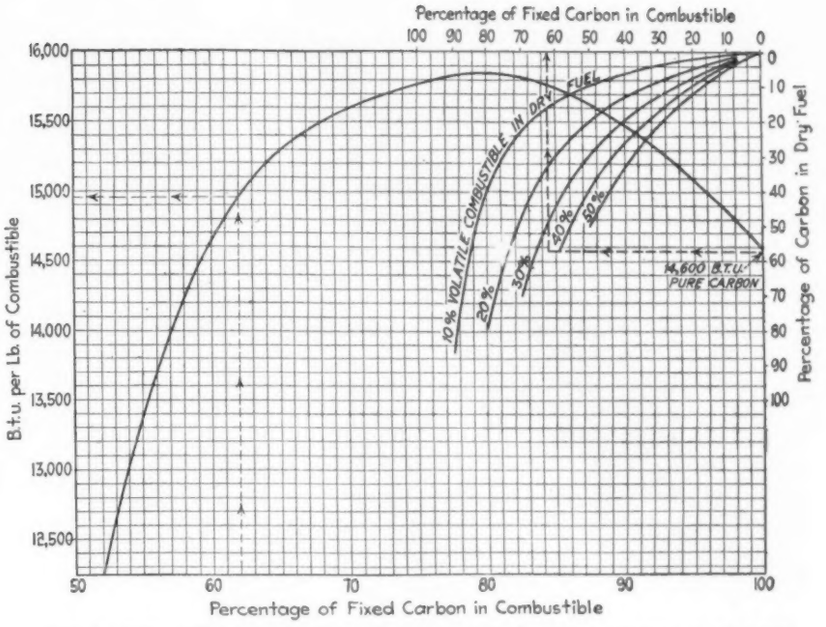


FIG. 2. RELATION BETWEEN FIXED CARBON AND THERMAL VALUE

The Use of Graphite in the Lubrication of Cylinders

By Frederic W. Carter*

SYNOPSIS—By the use of graphite used with cylinder oil at 32c. a gal. in a 22x40x48-in. George H. Corliss engine, a saving of $3.50 per week of 120 hr. is made over lubrication with straight oil at 48c. per gal.

There seems to be little information available except in a general way regarding graphite lubrication of cylinders. It is generally conceded that graphite is the proper thing for engine cylinders, but no concise or reliable data, especially as to cost of graphite lubrication as compared to lubrication without graphite, are to be had.

In the plant of which I have charge we have an excellent cost system and I know each month what the costs are for every item of power production. Consequently the minimizing of costs consistent with good continuous service is practiced.

The lubrication of the cylinders of our 22x40x48-in. 72 r.p.m. George H. Corliss engine was one of the matters receiving close attention. After experiments as to the least amount of oil that could be fed and not cause cutting or scoring of the cylinder, the consumption was brought down to where only a slight stain was obtained with a piece of white paper pressed against the walls of the cylinder. At this point the cost with a grade of cylinder oil at 48c. per gal. was $6.07 for a week of 120 running hours.

I determined now to try graphite in the cylinders, and immediately set about to find out who was using it and what results were being obtained, but could learn little about it. I found that while graphite had been tried in some cases, it was abandoned because of the inability of the feeding device to successfully get it to the cylinder walls and valves.

After consideration of the different types of graphite feeders, I found one made by an engineer and used in his plant, and installed it. With graphite lubrication the graphite is depended upon wholly as the lubricating agent, the oil being used merely as a carrier to convey the graphite. Consequently a cheap grade of cylinder oil can be used, it being necessary only to select a grade having a sufficiently high flash point to stand the temperature of the steam.

A grade of oil costing 32c. per gal. was selected. The graphite was started with the same amount of oil per hour, but was gradually cut down as each weekly inspection would allow, until at present we are using 27 qt. of cylinder oil per week of 120 hr., as compared to 50½ qt. without graphite.

In addition we are using 2 lb. of graphite per week of 120 hr., costing 20c. per lb. The cost then is $(27 \times 0.08) + (2 \times 0.20) = \$2.56$ to lubricate both cylinders for a week. Without graphite the cost was $50.5 \times 0.12 = \$6.06$. To compare then we have: Cost without graphite, $6.06; cost with graphite, $2.56; saving, $3.50. This represents a saving of 57½ per cent. in the cost of lubricating the cylinders of this engine.

*Chief engineer, Wright Wire Co., Palmer, Mass.

With this type of feed it is necessary to install one feeder on each line from the force-feed lubricator; in this case four were necessary, two to each cylinder. The total cost was $125.00 and allowing 6 per cent. as interest on this, the cost is $132.50. As the saving is $3.50 per week, it will take 39 weeks, or nine months, to pay for the feeders. So the investment pays well. This feeder has no mechanical moving parts and no repair charges can be made against it.

The graphite has been fed to the cylinders for three months and has given satisfaction. No trouble has been experienced with the lubrication or in properly getting the graphite to the valves and cylinders. The Saturday previous to this writing the cylinders were opened and found in excellent condition—as we sometimes say, "just like a looking glass."

I have been unable to make any tests for results as to friction, but there is this condition as an indicator: We have had no trouble with the dashpots sticking with graphite, whereas with cylinder oil alone we frequently made adjustments to prevent them from sticking.

Safety-First Notice for Steam Power Plants

Safety first has to all appearances got a grip on the country, for safety-first signs are seen wherever one turns. One that goes a little farther than most is illustrated herewith and speaks for itself. The sign is mounted in a concrete frame, which is bolted at each corner to the vertical structural-steel beams of the engine room.

Notice that the "man higher up" is not content to have the assistant report defects to the engineer in charge of the plant, but that, if the matter is not remedied at once, the assistant is to go over his head and report "higher up."

This idea is fine as far as it goes, in keeping the "man higher up" informed on power-plant shortcomings, but how long would the assistant have a job after reporting a defect to the chief of the watch and then to the "man higher up" if the matter were neglected?

However, the idea is a good one and by the presence of the notice every employee is given a direct order to report all defects found about the plant.

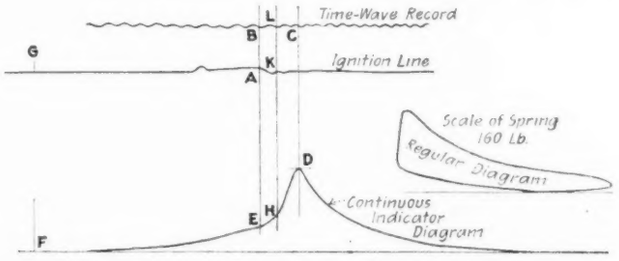
ENGINE-ROOM SAFETY-FIRST NOTICE

Explosion Period in Gas Engine

By R. S. King*

The accompanying diagrams are from a 6-hp. four-stroke-cycle hit-and-miss governed gas engine. The igniter is of the make-and-break type, and the governor, which is of the inertia type, was set up so that explosions would not be missed until the speed reached about 325 r.p.m. The speed was held constant by a prony brake, thus causing the engine to explode at every cycle.

Indicator diagrams were taken to determine the indicated horsepower, and a second indicator was arranged to produce a continuous diagram on a strip of paper. Simultaneously, a mechanism was used to record time waves. This consisted of a pencil driven by an electrically



TYPICAL DIAGRAMS SHOWING EXPLOSION PERIOD

vibrated tuning fork making 128 vibrations per second and recording on the continuous diagram. The difference in some of the wave lengths obtained by this device was due to the paper not moving with absolute uniformity around the roll. The record of the time when the spark occurred was obtained by attaching a pencil to a part of the igniter so as to move with it. The record shows when the points of the igniter came together and when they opened. From these records it was possible to obtain the time of explosion in the engine under actual running conditions—not in a closed vessel, as done by Clerk.

Referring to the diagram, the first variation in the ignition line is the point at which the igniter makes contact. It continues in contact until the break, which is shown at *A*. The time from the instant of ignition until the maximum pressure is reached is measured on the time-wave record from the point *B* to the point *C*, although the actual time of explosion should be measured from the beginning of the rise in pressure due to ignition. A short spark does not always ignite the charge but it must be of a certain length before ignition really begins. An inspection of the continuous indicator diagram shows that there was no apparent increase in pressure until a short time after the igniter points began to open, thus bearing out the point that explosion did not start until

*The author was assisted in these tests by Lloyd Yost and T. W. Stone.

the igniter points had opened a certain distance. Taking *H* as the point where an increase in pressure can be noticed, a vertical projection will cut the ignition line at *K* and the time-wave record at *L*, thus showing that the time required for the explosion to begin, or the flame to spread through the mixture, was *BL* and the real time of explosion, *LC*. Both the apparent and the actual time of explosion are given in the table.

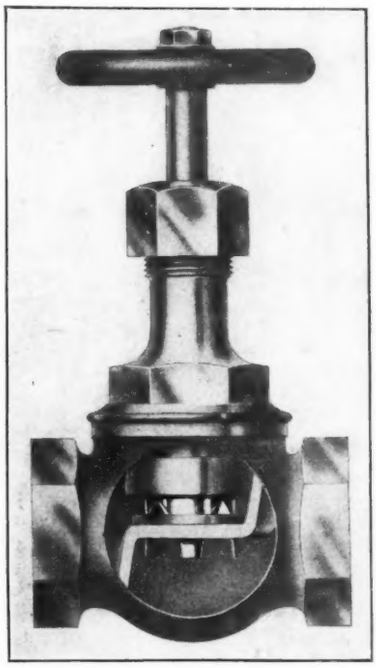
The gas used was ordinary coal gas, and it appears from the table that the rapidity of explosion is greatest with the best mixtures and also increases with the compression.

DATA TAKEN ON TEST

Diagram No.	1	2	3	4	5	6	7	8	9
R.p.m.	292	314	320	305	307	312	312	310	309
Exp. per minute	146	307	160	152	153	156	156	155	154
I. hp.	9.68	10.49	10.35	8.55	9.02	8.57	7.58	9.10	8.90
B. hp.	7.08	7.10	8.05	6.54	5.97	5.67	5.33	7.57	6.26
Outlet temp., deg. F.	153	204	185	174	173	171	168	178	177
Ratio air to gas	6.57	5.58	4.87	6.53	5.32	4.72	6.00	5.03	4.34
Cu.ft. gas per i.-h.p.-hr.	19.33	19.72	23.70	18.96	21.65	25.29	24.44	23.48	26.08
Cal. value of gas, b.t.u. per cu.ft.	687	687	687	679	679	679	682	682	679
Compression, lb.	56.4	52.4	55	63.6	62.4	61.0	73.8	76.6	72.4
Ratio max. press to comp.	3.06	3.25	2.75	2.13	2.38	2.05	1.90	2.53	1.96
Apparent time of explosion (sec.)	.0184	.0154	.0188	.024	.022	.024	.0195	.0121	.0258
Real time of explosion (sec.)	.0142	.0134	.0142	.014	.013	.013	.0139	.0106	.0135

Jenkins Valve-Throttling Nut

Hand-operated pressure-regulating or throttling valves have seldom been provided with any special disks or seats for properly regulating the flow of fluids through them. To supply this need a throttling nut has been placed on the market. The valve body, seat and disk are of the standard pattern, but the disk-nut is made of such size as to effect a loose piston fit in the seat. It is also provided with projections, as shown in the illustration, which furnish the proper orifices to restrict the flow of fluid so that the desired terminal pressure or the amount passing through the valve may be controlled. Wear from the wire-drawing effect is taken up by this throttling nut and the side of the seat.



THROTTLING NUT FOR GLOBE VALVE

This valve will be found useful as a steam-throttling valve for a pump, heating kettle or similar device, and also where the flow of water to a tank, boiler, etc., is to be regulated and where more valve seats are spoiled from the cutting action of the steam than in any other way. These throttling nuts are applicable to the full line of renewable disk valves made by Jenkins Bros., 80 White St., New York City.

Simple Compression Indicator

The instrument shown is known as a telometer and has been designed for determining the compression in pounds per square inch in the cylinders of internal-combustion engines, especially engines for automobile use or others in which the compression does not exceed 100 lb. The instrument is of simple construction and accurately calibrated. It is made to fit the various spark-plug threads by using the combination connecter shown at the left. The device comprises an accurately bored cylinder in which are fitted the piston and rod, backed up by a calibrated pressure spring. The pressure applied to the piston gives an upward motion to the drum in direct proportion to the pressure. By pressing the pencil against the drum, a vertical line is produced. As the card has a scale reading in pounds per square inch, the compression may be read directly. Provision is made on the card for readings from six cylinders.

INDICATOR WITH CHART IN PLACE

At the bottom of the cylinder is a gravity-ball check valve which cushions the piston in its return travel and prevents slamming on the seat. It will be noticed that a setscrew holds the lead in place. In case of breakage a hole through the handle permits poking out the lead. The instrument was patented by C. J. Zigler and W. P. Holden, both power-plant engineers, and is made by the Zighometer Manufacturing Co., 1307 North Waller Ave., Chicago.

Life Data on Power-Plant Equipment—In a valuation of the property of the Bay State Street Railway of Boston, Mass., recently submitted to the Massachusetts Public Service Commission in connection with proceedings for a proposed fare increase, a protracted study was made of the life of equipment by the consulting engineers of the company, Sloan, Huddle, Feustel & Freeman, of Madison, Wis. Estimates based upon an eighteen months' investigation of the system, which comprises nearly 1,000 miles of track, include the following life data:

Equipment	Life in Years
Boilers (water-tube)	25–30
Boilers (fire-tube)	20
Engines	30–40
Turbo-generators	20
Condensers (steam)	20–25
Pumps	12–20
Stokers	15
Heaters	25–30
Coal-handling machinery	25
Piping	25
Generators (direct-current)	30–40
Alternators	25

—"Electrical World."

Covering Steam Pipes

By J. C. Hawkins

In almost every power plant some pretense is made of covering the steam pipe to reduce condensation. In some cases, however, only the pipes are covered and the flanges, valve bonnets, etc., are left bare. The reason advanced for not covering these parts is that it is relatively more expensive, and it is sometimes necessary to make repairs that would necessitate the removal of the coverings, but the leakage caused by the expansion and contraction from exposure would be lessened. In covering small pipes the flanges and valves are covered without thought of leakage.

Sectional covering that is molded to fit the flanges and can readily be removed when necessary may be used or ground asbestos plastered on and broken off when it is necessary to expose the flange. The broken pieces may be made plastic and used again after the repairs have been completed. Where fittings are numerous there is considerable surface exposed.

Roughly, each 10 sq.ft. of exposed uncovered pipe will condense 105 lb. of steam during a day of 10 hr., and when covered, will condense only about 8 lb.

A table compiled by G. M. Brill gives the results of a large number of experiments in this respect and shows the radiation due to covered and bare pipes. Column 1 is the kind of covering, material; Column 2 is the B.t.u. transmitted per degree difference in temperature per square foot of pipe; Column 3, pounds of steam condensed per hour per square foot per degree difference in temp. in still air; Column 4, steam saved per 100 sq.ft. per year.

1	2	3	4
Bare pipe	2.7060	0.003107	000,000
Magnesia	0.3838	0.000432	635,801
Mineral wool	0.2846	0.000311	662,957
Manville sectional	0.3496	0.000409	645,174
Manville wool cement	0.3448	0.000410	646,988
Manville sectional and hair felt	0.2119	0.000243	682,930
Hair felt	0.4220	0.000472	625,376
Average	0.3327½	0.000379	649,871

To compute the possible saving by covering all parts of a given line, the covered and uncovered area was measured. In the main steam line and branches there were 900 sq.ft. of surface covered and 420 sq.ft. uncovered (not including the bolt heads and nuts, all of which radiate heat), or about 32 per cent. of the total left bare From the table the steam condensed per square foot of bare pipe per degree difference in temperature per hour is 0.003107. The steam pressure in our case is 100 lb., or 337 deg., and the room temperature averages 100 deg., leaving a difference in temperature of 227 deg. The system is under pressure and exposed to air currents 24 hr. a day 365 days a year, or 8,760 hr. per year. The loss from the exposed surface is therefore $0.003107 \times 227 \times 8{,}760 \times 420 = 2{,}594{,}890$ lb. of steam condensed per year. Of course, it is not possible to prevent some condensation, but if covered with magnesia the condensation per degree difference in temperature would be about 0.000432 lb. per sq.ft. per hr., and the loss would be $0.000432 \times 227 \times 8{,}760 \times 420 = 360{,}800$ lb. of steam, or a reduction of $2{,}594{,}830 - 360{,}800 = 2{,}234{,}030$ lb. per year.

Assume the coal costs $3.90 per ton of 2,240 lb. and evaporates about 10 lb. of water per pound of coal, then, the estimated saving per year by the use of covering is $\frac{2{,}234{,}030 \times \$3.90}{10 \times 2{,}240} = \$390.53$ for coal alone. The cost of handling the coal and ashes, together with the wear and tear on the boilers, etc., would more than offset the overhead charges on the covering, so that the saving would be in round numbers $400 per year.

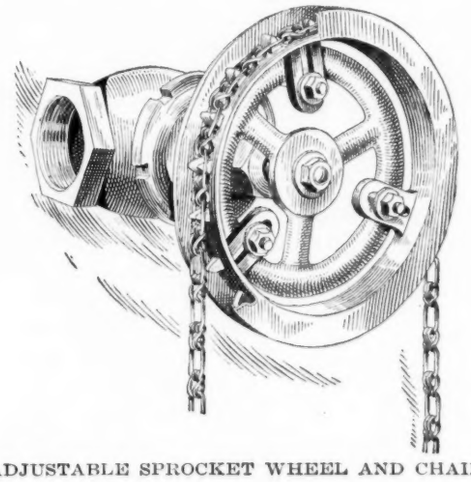
All covering should be looked after at least once a year and given necessary repairs, refitted to the pipe if loose and the space due to shrinkage taken up or filled with asbestos cement, for little can be expected even from the best nonconductors if they are allowed to become saturated with water of if air currents are permitted to circulate between the pipe and covering. The presence of sulphur in many coverings and its injurious effects on iron make it imperative that moisture be kept away from the covering, for moisture will combine with sulphur, making it active.

In short, keep the pipes covered and the covering in good repair, painted or varnished. Much of the inefficiency of coverings laid to faulty material is the result of lack of proper care after it has been applied.

Babbitt Adjustable Sprocket Rim

A convenient device for engine, turbine and boiler rooms is the Babbitt adjustable sprocket rim, illustrated herewith. It is made by the Babbitt Steam Specialty Co., New Bedford, Mass.

The rim will fit any valve handwheel and does not interfere with the movement of the valve stem. It is



ADJUSTABLE SPROCKET WHEEL AND CHAIN

made with adjustable hook-bolts which are hooked to the rim of the handwheel, the threaded end of the bolts passing through slots in the lugs of the sprocket rim. After the sprocket has been centered on the wheel, the nuts are set up tight and the attachment performs the service of the handwheel. The rim is made with a sprocket over which a chain is run, so that the valve can be operated regardless of the distance it happens to be located above the floor.

A Ton of Pure Limestone will burn to a little over half its weight of lime, or about 1,120 lb., which, counting 80 lb. to a bushel, would give 14 bu. of lime to a ton. The weight of the burned product, however, generally averages more than this, owing to impurities in the limestone, and also because in ordinary kilns the combustion is not complete enough to drive off all the carbon dioxide. A cubic foot of limestone averages in weight from 145 to 175 lb., which would make a ton of limestone contains from 11 to 14 cu.ft.—"Mechanical World," Manchester.

Editorials

Need of Co-operating with the Load Dispatcher

The load dispatcher is a specialist of comparatively recent development, the necessity of whose position arises chiefly from the importance of continuous service on highly complex electrical networks often involving the interoperation of a group of generating plants, transmission lines and substations. He serves as a sort of electrical clearing house and is successful in large degree according as he has the confidence and support of local plant operators, upon whom he must depend for information and to whom he issues instructions often in considerable detail.

In some cases the load dispatcher is responsible for the economical operation of plants under his general control, and the bearing of this responsibility upon his relations with chief engineers, substation foremen and others deserves consideration. In a nutshell, the system load factor determines the dispatcher's course, and from his knowledge of the capabilities of different generating plants, lines and substations, he exercises a control over the handling of apparatus that may sometimes look rather arbitrary to the competent station chief who is anxious to make the best possible showing in handling his own equipment. Every engineer worthy of holding his job is anxious first, last and always, to generate power at the lowest cost consistent with first-class service, and it is only natural that the reception of orders that tend to impair the operating economy of one station in the interests of improving the performance of another is sometimes disturbing.

The engineer or electrical operator who goes from a system served by a single plant to a system operating a group of stations should realize that new standards of service are here essential. With a capable management such a man will not be misjudged if the performance of his individual station varies a good deal as a result of the orders of the load dispatcher. In a combined steam and hydro-electric system this is especially true, and in the handling of interconnected but scattered water-power plants, perhaps supplied by different rivers, the efficiency of the individual plant must often go by the board in meeting the larger needs of the system as a whole.

Handling a station in a large system is a good deal like handling a regiment in an army corps, and the engineer needs to realize that if he does his part in operating his local installation as efficiently as he can under the conditions imposed, he makes good. The dispatcher is the only man who can see at a glance the diversified conditions prevailing over the entire territory; who can take advantage of local circumstances for the benefit of the entire property. The local engineer must not forget that at times other stations can be operated at far less cost than his own, because of their proximity to special loads of magnitude, unusually good supply of water, or opportunity to extract the last fraction of economy from a big generating unit turning out a huge volume of energy. There is always plenty to do in trying to get the best results possible out of even an auxiliary or a peak station, and if adequate records are maintained of the orders received from the dispatcher, with full operating data and log sheets, the faithful and competent engineer can dismiss from his mind the fear of being unfairly criticized and turn his whole attention to coöperative service.

*

More Lessons from the War

The significance of the European War to engineers the world over increases as the great conflict continues, and there is no end to the lessons it brings home to men of insight. It is the engineer's duty to learn what he may from the war, for it has its lessons even for the humble engineer operating a small country plant, for the station chief and for the fireman, however limited the range of their activities.

Much could be said of the fidelity to duty and the exhibitions of courage displayed by engineers in doing their mighty, though inconspicuous, part in this stressful period, and the loyalty and nerve which hold them to their posts regardless of surrounding conditions must command the homage of all, but there are other lessons which can be applied by every worker in the engineering field.

From the practical standpoint the war teaches the immense importance of details. For the time being, the individual subordinates himself to the general cause, and the resulting coöperation is nothing short of wonderful. Thinking of this team-play by whole nations, do not the petty jealousies that sometimes exist in plants on this side of the water seem pitifully trivial? Cannot we as a class seek the goal of maximum-efficiency service in our respective installations without making so much of the effect of every step on our own personal advancement? It is a high aim, this striving for collective efficiency, and there is something for the engineer to think about here.

Again, the war is a marvelous object lesson in accuracy—in the complete performance of each task required. The neglect of a single cylinder's lubrication by the mechanician of the aëroplane squadron may cause a machine to fall behind just the fraction in speed which enables it to be reached in flight by an anti-air-craft gun; or on the sea, the neglect of a turbine bearing may lead to the capture or sinking of a destroyer. There is no room for blundering in these issues, and the lesson should not be lost in peaceful service. And finally, there is the strategic advantage of "closing in." This is capable of being made a real inspiration to the ambitious engineer who can draw a parallel between the advance of the battlefield and his own progress toward increased proficiency. At the front every advance costs, every natural and artificial means possible must be utilized to gain short distances, and often a few rods of trenches represent an appalling expenditure of life and ammuni-

tion. The engineer can figure it out in his own case, plan his own campaigns against inefficiency and ignorance, struggle forward inch by inch to the mastery of new principles and problems, and by reviewing and collateral reading and discussion, "consolidate his own trenches," bring up his reserves and take permanent possession of those advanced fields of knowledge which occupy the best men in his profession.

Boiler Explosions in Germany

In the entire Empire of Germany, not including those used in the military and naval service, there were, in 1914, only eight explosions of steam boilers. One of these was built in 1873, one in 1874, one in 1880, one in 1881, one in 1892, one in 1902 and two in 1906. The dates are mentioned as showing that all the boilers were well along in years the most were of the last century. Low water is given as a probable cause in five out of the eight cases. In three of the explosions no personal injuries were caused. The other five killed two, seriously injured two and slightly injured seven persons.

In the same period there occurred in the United States 575 accidents to boilers, by which 300 persons were killed and 476 more or less seriously injured; and yet there are those who protest with all of the outraged righteousness of American citizenship imposed upon against any governmental control or supervision of the design and operation of boilers, or of the competency of the men that run them.

Boosting and Protective Unions and Professional Societies

Everybody looks with admiration and respect and hopeful interest upon the activities of a medical association dealing in a broad, professional way with the ills to which flesh is heir, although its complete success in the eradication of disease would mean the decimation of its membership. When, however, a crowd of doctors get together to discuss how large fees they can exact, to discredit those that cut prices, to blacklist patients that do not pay promptly, and to perpetuate their secret prescription system whereby the patient pays anywhere from thirty-five cents to a dollar for a tablespoonful of common salt, the public regards the association in quite a different light.

Recent movements in the engineering field have partaken somewhat of the latter character. In these days of combination and organization for material, mercenary and egotistical ends, it may be that there is as much reason for such unions to help and protect the weaker individual as there is at least in other professions. It cannot help having a sordid air, however, and our ideals will continue to hover about the more altruistic society of the first-named class, out of which type of development, after all, real progress must come.

The mercenary nerve is an excitable one and does not lead to thought centers and mental altitudes that afford a broad, unselfish view of life. The same touch that sets it aquiver with pleasurable anticipation in one group will arouse it in another to a quickened and discordant sense of apprehension and counter-attack. We understand that the association for materialistic benefit has already split upon the question as to whether it should give legal advice gratis to its members in patent matters—the secretary is a patent attorney. Much talk has been made in this society about the unethical conduct of engineers employed by selling companies that prepare plans and give free engineering advice to prospective customers; but patent attorneys that are not secretaries think that this activity of the society is much in the same line, and a new society, the Associated Technical Men. has arisen with the following announcement of its objects and purposes:

> Whereas, Under the present conditions of the technical profession there exists unintelligent competition, a lack of coöperation and organization, which is resulting in a decreasing rate of compensation among technical men, a consequent low social standing and a general lowering of ethics and honor of the profession from the former high standard;
>
> Whereas, The failure to secure suitable compensation is preventing technical men from development and from discharging their obligations to society and from taking the position in the social scale to which their professions entitle them;
>
> We, the body assembled, undertake to form an association which shall weld together in a common bond of interest all those who may be justly considered as engaged in technical pursuits.

Cheap (?) Hydro-Electric Power

The claim that the Federal Government by its attempted conservation policy is holding up hydro-electric development and thereby depriving the people of cheap electricity may have some influence on public opinion, but such experiences as that with the Keokuk plant are fast convincing the erstwhile misinformed that "juice" made hydraulically is not entirely a gift from Nature. Various important towns have discontinued purchasing current from the Mississippi Power Co. because they can make it cheaper themselves. Now the latest is that St. Louis has found out the same thing.

Hydro-electric power generally is less expensive than steam power, but there are conditions—physical ones, too, sometimes—that throw the balance the other way. In the case of Keokuk, however, the high cost of power is not altogether due to investment or operating expense. The administrators of the venture had had roseate dreams of the wealth they were going to annex when the system was running, and they proceeded to collect a little too boldly, taking too many profits out all along the line by doing their business through a chain of subordinate companies; so that the consumer has been forced to pay the former steam rates. It may be very true, as recently testified by one of the officials of the Union Electric Light and Power Co., of St. Louis, that this company is forced to pay a high rate for the hydro-electric power and therefore is not making much money, but as the same interests control this company and the numerous distributing companies, it is taking money out of one pocket and putting it in another as a matter of fact.

If they do not wake up shortly, they will find themselves in the predicament of the youth in the old fable, who took such a handful of gold that he could not withdraw his hand from the crock and had to drop it all to get his hand out again—"Try to get all and get none" is Æsop's way of putting it.

This is an age of engineering. The engineer is responsible for its greatest achievements, and his work is the basis of its comforts, conveniences and habits—and yet one may search the roster of Congress through without finding a single engineer in the list.

Correspondence

Cutting Down the Cylinder Oil*

Messrs. Anderson and Michael, in their articles on the subject of cutting down cylinder oil, bring up an interesting question. If Mr. Michael uses too much oil in his plant, either his oil is not suited to the work or his method of introducing it into the engine is at fault.

We have a Corliss cross-compound engine and use a single-feed force pump on the high-pressure side, introducing the oil above the throttle, and a three-feed pump on the low-pressure side, introducing the oil as the steam enters the steam chest and at a point in the path of the steam going to each admission valve. This engine averages 65 r.p.m. and oil is fed to the high-pressure cylinder one drop to every three revolutions; the steam is carried at 150 lb. gage, with 75 deg. superheat.

The pumps break up the oil into fine drops, and one drop equals about two of the average lubricator. On the low-pressure side one drop is fed from each pump every six revolutions. Three kinds of oil have been tried, two being of regular brands put up for general use. The one we are now using is compounded for our particular service. It is impossible to use less than one drop per two revolutions of the engine on the high-pressure side, but experiments are still being made with the low-pressure cylinder.

We also have a 20x40-in. uniflow engine on which we use a four-feed pump, one feed connecting at the throttle, one to the piston-rod stuffing-box and one to each valve. Special grooves distribute the oil to the wearing surfaces on the valves. This engine runs at 150 r.p.m., and one drop of oil is fed to each eight revolutions, this being as low as our pumps will feed.

The modern tendency is not to feed less oil, but more and to reclaim and re-use it. This can be done at small expense in the average plant. We reclaim an average of 75 per cent. of the original oil used. The principle is the same as generally used for engine oils. Oil from the air compressor is also reclaimed, purified and re-used.

Metallic packings are used on all piston rods, and it pays to lubricate them freely; in fact, it pays to lubricate any piston rod regardless of the kind of packing used. The best obtainable are used on our units, and I have never encountered any that had sufficient lubricating properties to properly lubricate the rod after the packing had been in use for any length of time.

Ringwood Manor, N. J. A. A. BLANCHARD.

Mr. Michael does not give enough information regarding the conditions in his plant for one to advise any definite method of procedure to obtain a minimum cylinder-oil consumption. The following suggestions may be of some assistance to him:

The lubricator may be removed from the low-pressure cylinder, if the system of feeding the oil is such that it is atomized before entering the high-pressure cylinder. In this case all wearing surfaces may be efficiently lubricated, and enough oil will be carried to the low-pressure cylinder to insure proper lubrication. The atomization of the oil would also allow the removing of the oil cups from the piston rod, whether metallic packing is used or not.

The temperature of the steam must be taken into consideration, also the percentage of moisture in it. The higher the flashpoint of the oil the smaller the quantity necessary, because it will not disintegrate as rapidly. As a rule, the higher the flashpoint in mineral cylinder oils the higher the viscosity; therefore the high-flashpoint oil will also have greater body, and a smaller quantity will be needed than of a lighter-bodied oil.

If the steam contains a high percentage of moisture, the oil may or may not be compounded with sufficient fatty oil to take care of this factor. Mr. Michael says that upon cutting down the cylinder oil the valves rattle. This may be caused by the lack of sufficient adhering property of the oil, because the percentage of fatty oil is too low to cope with the moisture in the steam and is washed off.

Where boiler compounds are used in excess, the strongly alkaline condensation may saponify the fatty oil, making it possible for the mineral oil to be washed from the wearing surfaces. There may be bright spots on the faces of the wearing parts, or the edges of the valves and piston may have become so sharp as to make it impossible for the oil to get in between the working surfaces. A fine file will remedy this condition.

New York City. L. F. LYNE, JR.

*See "Power" Nov. 2, 1915, p. 602, and Nov. 30, 1915, p. 763.

Live Steam vs. Exhaust for Heating*

I have been interested in the discussions in your correspondence pages regarding the difference in the steam consumption of a heating system, depending on whether exhaust or live steam is used. There is also a question as to which does the heating better. The continued discussion of this subject indicates that it is an important one with many, and the following experience which recently came to my attention, may be of interest.

A steam-flow meter was installed on a steam line to an engine, the same line also supplying, through a reducing valve, the live steam required in addition to the engine exhaust to keep up the pressure on the heating system.

It was found that the least steam was drawn from the boilers when the engine was running. In other words, when reducing the steam pressure by passing it through the engine less was consumed than when all the steam went through the reducing valve.

Does the pulsation of the engine exhaust explain it?

Philadelphia, Penn. H. A. HOFFMANN.

*Previous discussion on page 590, Oct. 26, page 761, Nov. 30, and page 831, Dec. 26, 1915.

Cannot Increase the Vacuum

Referring to Mr. Warren's letter, *Power*, Dec. 7, p. 797, on the loss of vacuum with a Corliss engine at Lynchburg, Va., nothing is said as to whether the piston-rod stuffing-box had been examined for a possible leak. Such a leak will produce the peculiar conditions mentioned, namely, 26 in. of vacuum when the engine runs light, and 23 in. of vacuum when the load comes on.

With a light load the back pressure in the cylinder is not far different from atmospheric pressure, so that there is very little leakage of air from the outside atmosphere through the stuffing-box into the cylinder. When the engine is loaded, however, the back pressure drops below atmospheric, and there is leakage of air into the cylinder, because of the difference in pressure of the air outside and the vacuum within the cylinder.

A small leak past the stuffing-boxes means a loss in vacuum. A stuffing-box leak may be caused by poor packing, or by the box not being well packed, of by a worn piston rod. The correction of such a leak will enable the carrying of a higher vacuum.

Walpole, Mass. DAVID FLIEGELMAN.

R. O. Warren's letter recalls to mind a plant that had always given about the same trouble. The Corliss engine, of 250-hp. rating, was equipped with a jet condenser. After examining the condenser and piping and finding that they were in good condition, I began to suspect that the exhaust piping was in some way restricting the passage of the steam from the engine. With that theory in mind I removed the gate valve between the automatic atmospheric exhaust and the condenser and found that it did not open as it should, owing to a defect in construction. Luckily we had a new valve on hand; it was put in, and the trouble ceased.

It is possible that such is the case at the plant referred to by Mr. Warren. I would suggest that the exhaust piping be figured to see that it is of ample size to carry the increased amount of steam at full load, and if so, then it would appear that the condenser is too small for the service. T. JEFF CRAVEN.

Waycross, Ga.

I would suggest that a thermometer be placed on the discharge pipe of the condenser pump and the difference in readings noted during the light and the heavy loads.

The trouble may be caused by either too much injection water or not enough during the heavy-load periods. Most likely it is due to lack of sufficient condensing water caused by a dirty strainer or screen. In either event the thermometer will indicate which it is and will be of value in determining the amount of injection water required. It would be interesting to know what is done to overcome the difficulty. J. M. COLEMAN.

Somerville, Mass.

It appears to me, from the data furnished, that the exhaust pipe is probably too small, or it is a long line with many elbows or sharp bends or both. Either condition would increase the velocity at full load and reduce the vacuum if recorded at the engine.

I experienced a similar trouble once while operating a simple engine condensing. At light loads the vacuum recorded at the engine was about 25 in. Increasing the load resulted in a gradual decrease in the vacuum up to full load, where the vacuum remained at 17 in. I computed the velocity of the exhaust steam at full load and found it to be about 25,000 ft. per min., which was excessive and accounted for the drop in vacuum.

Union Hill, N. J. WILLIAM SMITH.

In the case cited the type of condenser, the kind of pump and how driven are not stated. It it probable that it was a jet condenser with an independently driven reciprocating pump. I have frequently experienced similar conditions where the surplus load on the pump occasioned by the added condensate would slow it down, the pump throttle having been set to keep the vacuum right for the light load.

When any amount of speeding-up proves unavailing the trouble may sometimes be traced to a clogging of the pump suction. Frequently there is a stoppage of foreign matter in the condenser itself. Sufficient water may pass for the needs of the light load, but not enough for the heavy. Leaky pump valves often render inefficient circulation for loads above a certain limit. Upon one occasion a cracked valve deck was found to be responsible for just such a condition as the engineer described. In the case of large pumping units where there is an emergency relief in the suction and the condensing water is taken from the suction line, the relief valve sometimes admits air, destroying or impairing the vacuum.

Vacuums are sometimes lost or impaired by cutting-in to the steam line boilers which have an accumulation of air in them. It is possible that air may be injected into the boilers with the feed water when the supply is very hot. EDWARD T. BINNS.

Philadelphia, Penn.

Care of Gas and Oil Engines

In looking over the advertising columns of *Power* recently I saw a statement that might easily be misconstrued by those not familiar with gas and oil engines. The statement was to the effect that even in units of the largest sizes the engine advertised requires the attention of only one man and that only for a part of the time; that after starting up in the morning, he need never go near the engine until it is time to shut down, except to fill the lubricator reservoir and see that the fuel-oil tank is supplied; and that the engineer of a steam plant has to be an expert licensed by the city or state and his services bought at a correspondingly high price whereas a comparatively inexperienced man can be put in charge of the oil engine with perfect safety.

The idea that a gas or oil engine will take care of itself any more than a steam engine and that the owners can put any man about the place in charge of it with perfect safety was exploded long ago. It is only the inexperienced business man who would take these statements seriously, and if the engine were installed with the idea that any laborer about the plant could run it, trouble would be likely to follow, and the builder or some outsider would have to be called on to make minor adjustments. As a result the engine would probably be replaced with some less efficient type because it was better understood and would be given the amount of attention that any engine should have. This has been done in more than one instance.

It is true that a natural-gas or an oil-engine plant will require less labor than a steam plant of the same size on account of the absence of the boilers, but the oil engine requires more attention to keep it in good condition than a steam engine because of the high pressure carried and the tendency of the oil to carbonize on the valves and in the cylinder, especially if a low grade is used.

I am acquainted with the engine in question and believe that it is reliable in every respect, but it will not take care of itself and requires just as much attention as any other engine of the same kind.

The greatest drawbacks that the builders had when the gas engine was first put on the market were just these same statements, that the machine needed no attention; and it was not until builders began to recommend that the gas engine be given the same operating attention, as the steam engine and by a man of the same degree of intelligence as the steam engineer, that the gas engine began to hold its own. In visiting gas-engine plants I find that just as competent men are employed as in steam plants of a corresponding size and moreover, in some cases, at higher salaries than are paid in the latter. J. C. HAWKINS.

Hyattsville, Md.

Meaning of "Heavy" or "Light" Steam Gages

Information was asked under "Inquiries of General Interest," in the Nov. 30, 1915, issue of *Power,* in regard to the meaning of "heavy" or "light" steam gages. This question comes up about as periodically as the "hen-and-a-half, egg-and-a-half, day-and-a-half" problem and generally with the same result.

I am of the opinion that this question could be settled for all time by dropping the terms "heavy" or "light" when applied to a gage and simply stating the condition of the gage as you would that of a watch or clock. If your watch or clock is two minutes ahead or behind the correct time, you say that it is two minutes fast or slow, as the case may be. I have used these expressions for many years and have never stirred up an argument.

Plymouth, Mass. W. R. MORTON.

Another Filing Suggestion

Filing information by some such method as that pointed out by S. H. Viall in the issue of Dec. 14, page 829, is very important to anyone who is interested in keeping uptodate data.

At first I found it difficult to find any of the information after the first reading, but have hit upon a plan of indexing or filing which I think is very good. I cut out the whole page or pages and cross off any matter not desired, then clip these pages together and mark on the top of the page the title and the number of the page, plain enough to be seen at a glance.

The next thing is to get the index or contents page and clip out the title of the article indexed, with the page designated. These small pieces are divided into classes, such as boilers, engines, turbines, and pasted on oblong pieces of paper 3½x6 in. These papers in turn are put, according to class into small envelopes of about the same dimensions labeled at one corner. A number of these envelopes held together by a rubber band occupy only a small space in the pigeonhole of a desk. The pages from each issue are put together in order and put into a cover and the year marked on the outside.

Small clippings, such as inquiries of general interest and various other important data, I paste into a book under classified headings, allowing a certain number of pages for a subject, so that when the book is full, I can make out an index and have a valuable practical handbook. In another book I keep tables, such as wire, air, water, etc.

This gives me reliable information in a minute's time, and I am sure that anyone doing the same will soon have a first-class up-to-the-minute library.

JACK STROM.

New York City.

Difficulty with Suction Line

In the issue of Dec. 21, page 867, there appears an article under the caption, "Difficulty with Suction Line."

There seem to be several good reasons why there should be trouble. Starting at the supply end, there are two 24-in. lines which join into one 36-in., the combined area of the two 24-in. pipes is 904 sq.in., while the area of the 36 in. is 1,017 sq.in. The sudden change in size will result in a loss. The same holds true where the pipe changes back to 24-in. Such changes should be gradual.

It is usually advisable where possible, to take advantage of the velocity head, and each pump connection would be much improved by the use of a Y in place of a T. I believe that much of the trouble with the centrifugal pump comes from the changes in pipe size and the T near its suction. Reduction and increase in pipe size should be by means of reducing or increasing sections rather than as shown. All bends should also be long-turn sweeps rather than elbows. HENRY D. JACKSON.

Boston, Mass.

Tungsten vs. Carbon Lamps

The editorial in the Nov. 23 issue on "Carbon Lamps in Isolated-Plant Service" is good, but I have found that tungsten lamps, as now made, are too fragile for some kinds of service.

For sockets and fixtures where not much vibration will occur they are very well suited, but for drop-lights, portables, etc., they are liable to break just when needed. They are used in trolley cars, in spite of excessive vibration, because of their brilliancy. W. T. OSBORN.

Newark, N. J.

Engineers' License Laws

In the issue of Dec. 7, page 800, the article by A. C. Ruhl reveals the true position of a large majority of chief engineers in New York City also, those working for large corporations having what is called a supervising engineer, who is in most cases without a license and often not even a citizen of the United States.

The licensed chief engineer is given the title, but is to all intents only a foreman over the men employed in and around the plant. He can hire or discharge only after a consultation with his superiors. He is never consulted on questions of new additions or installations out-

right, but by indirect conversation his views are obtained. In this way the employer gains offhand what the engineer has devoted the best years of his life to learning. If there are any mistakes made and loss of life, the licensed engineer is held by law and must lose his license and in some cases serve a prison term.

I think, with few exceptions, corporations having a number of plants would save money by having their chief engineers attend meetings with directors or owners where plans for the betterment of the various plants could be discussed. This would promote harmonious action among the chiefs and give each a feeling of personal responsibility for the proper management of the plant in his care. Safety first, then economy.

New York City. JOHN C. SCHENCK.

Operating Without Gage-Glass

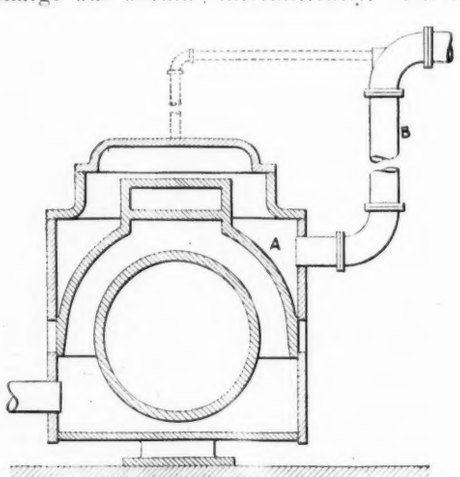
I was passing where there was a hoisting engine in use, and during a lull in the work I stopped to chat with the engineer. I noticed that the gage-glass was missing and remarked concerning the matter. "Yes, it broke a few days ago. When I get a little time to spare I'll put a new one in," said he. "How do you manage about the water level?" "Oh! whenever I think of it, I try the bottom gage-cock. That gives me an idea about where the water level is." It was my move and the further away I got, the better I felt. Not only was his own life placed in danger, but the lives of those near-by depended on his thinking to try the gage-cock.

Middletown, N. Y. G. T. MICHAELS.

Pump Efficiency Improved

The vacuum pump on a battery of condensers failed to maintain the necessary 26 in. vacuum. The cylinder and packing were both in good order, and although the valves and seats were not in the best condition, with the water seal they should have done well.

Starting the pump and watching it awhile, I noticed the discharge was working intermittently. There would



AIR RELIEF CONNECTION APPLIED TO PUMP

be a discharge of two or three heavy slugs of water, a few discharges of air and then nothing for several strokes; then the same cycle would be repeated. The illustration shows the discharge at the side of the pump and a seal in the discharge pipe intended to maintain a water seal over the valves. As the pump was discharging a mixture of air and water, the air would go to the top of the space above the valves, and the only way for it to get out was through the same pipe that discharged the water, and to accomplish this it would have to accumulate enough pressure to force the water out ahead of it. As the air pressure accumulated in this chamber, the water level would go down in the passage *A* and rise in *B* until the pressure became high enough to force the water over; consequently there was no water seal over the valves, because the water would be lower in *A* at any time than the level of the discharge-valve deck.

From a ¾-in. hole in the center of the top of the valve cover, we connected a ¾-in. pipe to a tee in the discharge pipe. When the pump was started again, the vacuum gradually increased until it reached 26.5 in., which was more than had been obtained when the pump was new. The ¾-in. pipe allowed the air to escape and maintained the water seal over the valves. The extra pressure and no seal over the valves, with the original piping, of course increased the leakage and reduced the capacity of the pump. THOMAS G. THURSTON.

Chicago, Ill.

Testing Condenser Tubes

With regard to W. Wolgast's comment in the issue of Nov. 30, page 764, on Junior Parrish's method of testing condenser tubes in the issue of Nov. 2, page 624, he probably did not get the correct idea. The possibility of error in Mr. Wolgast's method, which I have also used, may be clearer if he will consider a tube with a slight split in it subjected to an external pressure all around its circumference. The pressure will tend to close the crack, and the amount of leakage may be so small as to be overlooked. Since time is limited when testing condenser tubes in an operating plant and one cannot give the condenser time to dry previous to a test (at least I never could), a condenser tested in this way may look good enough but may, when in operation, be leaking a great deal.

I consider Mr. Parrish's method a good one, as there can be no mistake about a leaking tube. As to the expense, a faulty test failing to expose a leaky condenser may prove to be more expensive. A device such as that used by Mr. Parrish can be made from material at hand and produce the same results.

Trenton, N. S., Canada. J. A. MCGILLIWAY.

Counting High Speeds Mentally

Few realize the comparatively high speeds, either rotating or reciprocating, that can be counted on the finger tips after a little practice. I have counted as high as 600 r.p.m. and believe I can do better.

The best way is to allow the projecting end of a setscrew or key to just touch the tip of the finger and count up to ten only, then change to the next finger and count as before or make a mark with the other hand for each ten counted. It is seldom necessary to count for a full minute, as one half or even a quarter of a minute's count will give the correct speed. The number of check marks in one minute multiplied by 10 will of course be the r.p.m. S. F. WILSON.

New York, N. Y.

Inquiries of General Interest

Dynamic Head of Pump—What is the dynamic head of a pump? J. F. D.

The resistance, considered as head, that opposes the operation of the pump in overcoming inertia of the water or other liquid pumped.

Tools for Trimming Joints of Leather Belting—For ordinary power-plant use, what tools can be conveniently employed for scarfing the ends of leather belting preparatory to splicing and cementing? E. C. S.

The rough trimming can be done with a broad wood chisel having a convex curved edge, or a broad knife having a curved edge and a handle similar to an ordinary single-bladed kitchen chopping knife. The surface of the joint can be evened with a carpenter's smooth plane and made as smooth as desired by scraping with glass.

Excess of Air Injurious in Melting Brass—In melting down brasses would the introduction of large quantities of air into a closed crucible change the nature of the metal or injure it in any way? E. C. Q.

The introduction of large quantities of air into a closed crucible while melting brass will change the nature and injure the metal—first by oxidizing the zinc faster than the copper, rendering the final product too high in copper, and later there begins to form a suboxide of copper which dissolves in the brass, lowering its tensile strength and elasticity, and if enough of this suboxide is formed the metal becomes "short."

Radiation of Heat from Oiled Surfaces—What reason can be assigned for more rapid loss of heat from a metallic surface that is coated with oil than from one free from oil? J. W. D.

Dry metallic surfaces even when highly polished are composed of innumerable cavities forming pockets for air that is practically stationary and that acts as a nonconductor of heat. Oil being a better conductor of heat than stationary air, probably when the cavities are filled with oil there is more rapid transfer of heat to the atmosphere circulating over the oiled surface. There is also some absorption of heat by the evaporation of the oil.

Pumpage with 100 Ft. of Piston Speed—How many gallons of water per hour will be handled by a duplex pump having water cylinders 12 in. diameter and piston rods 2½ in. diameter when operated at a piston speed of 100 ft. per min., allowing 7 per cent. slippage? R. L. G.

Each piston will have a gross area of $12 \times 12 \times 0.7854 = 113.1$ sq.in., and as the cross-sectional area of each piston rod is $2.5 \times 2.5 \times 0.7854 = 4.9$ sq.in., one side of each piston will have a net area of $113.1 - 4.9 = 108.2$ sq.in. and the average effective area of each water piston will be $(113.1 + 108.2) \div 2 = 110.65$ sq.in. With a piston speed of 100 ft. per min. the total piston displacement per hour would be $2 \times 110.65 \times (100 \times 12) \times 60 = 15{,}933{,}600$ cu.in. $= \frac{15{,}933{,}600}{231}$, or 68,976.6 gal., and with 7 per cent. slippage the pump would handle $68{,}976.6 \times (1.00 - 0.07) = 64{,}148$ gal. per hr.

Trouble From Air-Bound Water Pipes—What causes water-pipe lines to become air-bound, and how can the trouble be overcome? R. E. A.

Air held in solution in water is liberated by reduction of pressure, and reabsorption of the air by the water is comparatively slow, even when the water is atomized or violently agitated. When thus liberated the air usually gathers at the high spots in a pipe line in an aggregation of bubbles, first adhering to the upper surface of the pipe and frequently gathering to such an extent as to completely fill the pipe. The bubbles adhere to the pipe with considerable tenacity and often require extraordinary pressure for their dislodgment, especially when formed in water containing impurities that increase its viscosity.

Air bubbles thus formed in small pipes, like boiler-feed lines, can frequently be loosened from the pipe or can be broken up by tapping the pipe with sharp blows of a hammer. Provision can be made against the trouble by providing pet-cocks at the high places in the pipe line for occasionally relieving the pipe of air or, better where practicable, the cocks should be left open or allowed to leak a very little all of the time. Large pipe lines, such as those used for municipal water-supplies, are frequently provided with air-relief valves operated by floats.

Nonfreezing Solutions for Low Temperatures—What proportions of calcium chloride and water will not freeze at 40 deg. below zero F., and what other nonfreezing mixture is good for motor radiators for 40 deg. below zero F.? F. E. W.

About 5¼ lb. of calcium chloride to one United States gallon of water, or about 6½ lb. to a British gallon, would be necessary to avoid freezing at 40 deg. below zero. Care must be taken that the brine is not acid. If it turns blue litmus paper red, milk of magnesia should be added until the acid is neutralized. A good mixture for use as an antifreezing solution for motor radiators consists of alcohol and water, sometimes with glycerin added. As low a temperature as minus 40 deg. F. would require a mixture of about equal parts of alcohol and water. The more alcohol the lower the freezing point, but it is better to make a solution for a temperature only a little lower than expected, as the greater the proportion of alcohol the quicker the mixture heats when the engine is running. Glycerin helps to keep down the boiling point.

Actual Ratio of Expansion in Compound Engine—What would be the actual ratio of expansion in a compound engine having a high-pressure cylinder 14x36 in. with cutoff at ⅓ stroke, and a low-pressure cylinder 30x36 in. with 5 per cent. clearance in each cylinder? H. P. A.

The actual ratio of expansion would be the piston displacement per stroke in the low-pressure cylinder plus the clearance, divided by the volume of steam in the high-pressure cylinder at the time of cutting off. Having a low-pressure cylinder 30 in. diameter by 36 in. stroke and 5 per cent. clearance, the piston displacement per stroke plus clearance would be

$$(30^2 \times 0.7854) \times 36 \ (1 + 0.05) \text{ cu.in.}$$

and with cutoff in the high-pressure cylinder at ⅓ stroke and 5 per cent. clearance, the volume of steam in the high-pressure cylinder at the time of cutting off would be

$$(14^2 \times 0.7854) \times 36 \times (0.33 + 0.05) \text{ cu.in.}$$

Hence the actual ratio of expansion would be

$$\frac{(30^2 \times 0.7854) \times 36 \times 1.05}{(14^2 \times 0.7854) \times 36 \times 0.38} \text{ or } \frac{30^2 \times 1.05}{14^2 \times 0.38} = 12.68$$

Equivalent Evaporation from and at 212 Deg.—A boiler generates 1,000 lb. of steam per hour with a quality of 98 per cent. If the gage pressure is 100 lb. per sq.in. and the feed-water temperature 100 deg. F., what is the equivalent evaporation from and at 212 deg. F.? H. C. M.

A gage pressure of 100 lb. per sq.in. would be equivalent to about 100 + 15 = 115 lb. absolute. From the steam tables it is found that a pound (weight) of dry saturated steam at 115 lb. absolute contains 1,188.8 B.t.u. above 32 deg. F. and the heat contained in a pound of water when at the same temperature and pressure, called the heat of the liquid, is 309 B.t.u. above 32 deg. F.

With the feed temperature at 100 deg. F., each pound of feed water evaporated into dry saturated steam would receive $1{,}188.8 - (100 - 32) = 1{,}120.8$ B.t.u. and each pound of water entrained in the steam and remaining unevaporated would receive $309 - (100 - 32) = 241$ B.t.u.

As the quality of the steam generated was 98 per cent. dry, then each pound of feed water received 98 per cent. of 1,120.8 B.t.u. + 2 per cent. of 241 B.t.u. = 1,103.204 B.t.u., and as the latent heat of evaporation of water from and at 212 deg. F. = 970.4 B.t.u., then the factor of evaporation is $1{,}103.204 \div 970.4 = 1.13685$. Therefore generation of 1,000 lb. of the steam, under the conditions stated, was equivalent to the evaporation of $1{,}000 \times 1.13685 = 1{,}136.85$ lb. of steam from and at 212 deg. F.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Steam-Jet Refrigeration*

By J. C. Bertsch†

SYNOPSIS—A description of the Westinghouse-Leblanc system of refrigeration by expansion into a vacuum, using only water as the refrigerating fluid. The system is particularly suited to places where safety is the chief consideration. The method is not economical for temperatures lower than 30 deg. F., though the author announces improvements that have produced a temperature of —18.5 deg. F. Based on heat consumption, the author's calculations show a horsepower per ton equivalent of 0.67 for ammonia and 0.62 for the steam-jet system.

In the desire to substitute mechanical refrigeration for the direct use of ice, the dangers attendant with ammonia, carbon-dioxide and sulphur-dioxide sometimes even prohibit their application. Where these dangers must be eliminated and safety is the chief consideration, the question of economy is of minor importance, and any process suitable for obtaining the end in view, even if less economical, is desirable.

The process of steam-jet refrigeration is safe because no chemical is used; ordinary water is the sole refrigerating fluid. The use of water as a refrigerating agent is old, as demonstrated by the vacuum machines of Leslie, Carre, Windhausen and others. The credit of making use of water as a refrigerant a commercial success is due to Maurice Leblanc, of the Westinghouse Co. of France, and the devices for its operation are therefore called the Westinghouse-Leblanc refrigerating apparatus. An installation is shown in Fig. 1.

This refrigerating process is analogous to that going on in a cooling tower. In both, the liquid to be cooled must be divided into a fine spray for part of it to be rapidly evaporated. But instead of evaporating at a relatively high temperature and at atmospheric pressure as in the cooling tower, it must be evaporated at low temperatures and low absolute pressures, or, in other words, under a high vacuum.

Again, instead of absorbing the vapor by natural currents of air of varying humidity, which is not dependable, the vapors must be disposed of by force and in predetermined quantities. The substance to be cooled, which may be water, brine or any aqueous solution, is cooled directly within the apparatus without the use of any special cooler or other auxiliaries, and since the cooling is performed by evaporating part of the substance, this process is at the same time one for concentrating liquids or one for cooling and concentrating combined. These features are important to dairies, sugar refineries, breweries and chemical works, as they dispense with the concentration by heat and perform the cooling and concentration in one operation.

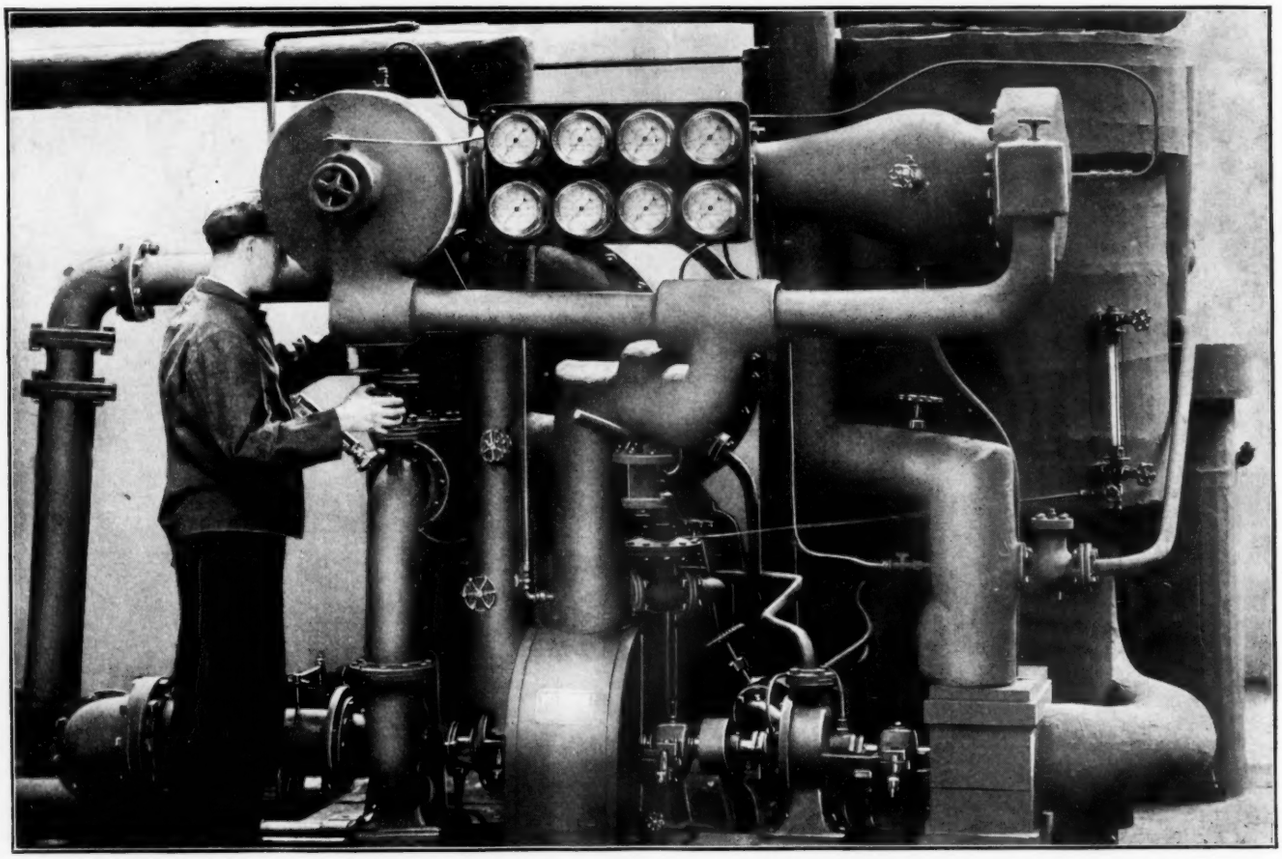


FIG. 1. A WESTINGHOUSE-LE BLANC SYSTEM OF REFRIGERATION IN OPERATION

For temperatures above 35 deg. F., as required for water-cooling or air-conditioning plants, water only is used as the heat absorber, or "cold carrier," but for all other purposes, where lower temperatures are required, brine is used. The apparatus for circulating the cold brine for cooling rooms, making ice or performing any other secondary cooling is in this process the same as in any other.

Referring to Fig. 2, the surge tank A is an equalizing and storage tank into which the return brine from the cooling coils is discharged and from which the evaporator is fed.

Since the brine is cooled by evaporating part of its water, it would become more and more concentrated until finally nothing but salt would be left. To prevent this and to automatically keep the brine level, as well as the density and

*Abstract from a paper before the December, 1915, meeting of the American Warehousemen's Association, New York City.

†Consulting refrigerating engineer; now with the Westinghouse Machine Co., East Pittsburgh, Penn.

quantity of the brine normal, this tank has a float-regulated makeup water inlet, which receives its supply from the coldest water available. The contents of this tank are under atmospheric pressure.

B consists of a closed vessel containing a vertical cylindrical partition for dividing the interior into separate brine and vapor spaces. Another horizontal partition near the top, which is closed for the vapor space and perforated for the brine space, forms with the top head of the vessel a brine-receiving chamber into which the return brine from the surge tank is sucked by the vacuum maintained in the evaporator.

Passing through the perforations, the brine is broken into a fine rain, which falls to the bottom, and, being exposed to the high vacuum, is cooled by the evaporation of a part of its water. The cold brine, kept in ebullition by the high vacuum, accumulates at the bottom of the evaporator, flows into the brine pump and is delivered to the place of secondary cooling, indicated in the diagram by a coil C. The action of the ejector D, which will be explained hereafter, causes the vapor to rise within the annular space formed by the vertical brine cylinder and the shell of the vessel, and discharges it into the condenser E.

The usefulness of the evaporator as a concentrator is in evidence, as by a continuous circulation of the substance to be treated, maintenance of the proper vacuum and feeding the surge tank with the circulating substance, any desired concentration and temperature can be obtained, as only the water

The fundamental feature of the Leblanc ejector, Fig. 3, is the application of the De Laval expanding nozzle, such as is used in turbines, which produces an approximately linear jet of steam of a kinetic energy nearly corresponding to the total drop of pressure, the efficiency being about 95 per cent. One of the De Laval nozzles applied to a turbine wheel is shown in Fig. 4. In the nozzle no external work is performed, but work manifests itself by an enormous increase in velocity.

Leaving the nozzle at such a great velocity, the steam creates a high vacuum or suction and carries with it the vapor coming from the evaporator. If this velocity would remain the same until the steam reaches the condenser, then the pressure, and consequently the temperature in the evaporator, would be limited to that in the condenser and the refrigerating effect would be small, since the temperature in the condenser is from 85 to 100 deg. F.

To obtain the highest efficiency the nozzle areas must be small, but as a certain quantity of steam must be expanded to perform a given amount of refrigeration, the total area required for the passage of the steam is divided into many small nozzles, as shown in Fig. 3. Each of these produces one independent steam jet, the surface of which creates a friction with the vapor from the evaporator and carries the vapor with it. Therefore the more surface produced for a given amount of steam the greater the refrigerating effect.

A refrigerating effect of about 50 deg. F. temperature difference can be produced with one ejector; that is to say, if

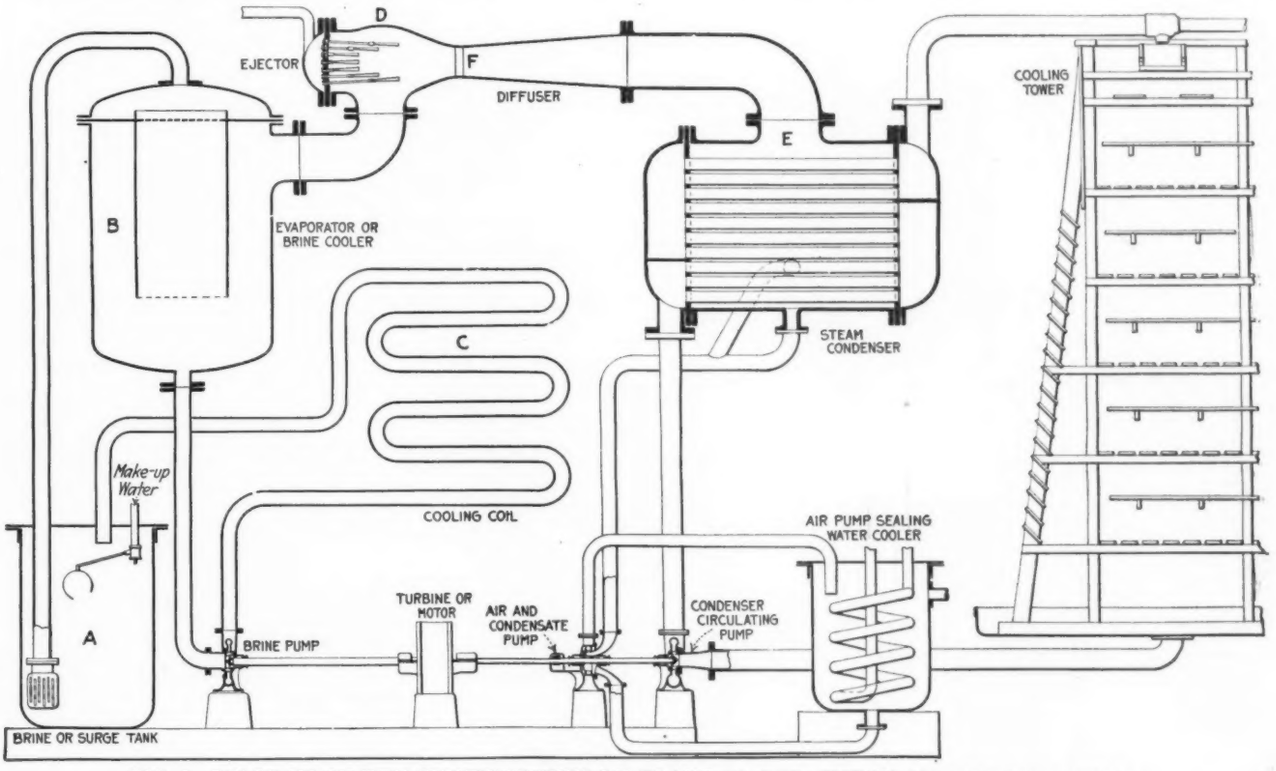


FIG. 2. DIAGRAM OF THE WESTINGHOUSE-LE BLANC WATER SYSTEM OF REFRIGERATION

of the aqueous solution is evaporated, and the ingredients in solution remain in the bulk of the substance, unchanged and well preserved, which is not always true of the products concentrated in the old way by heat.

The most important requirement of the brine pump is a stuffing-box that excludes practically all air.

The most important part of the apparatus is D because it produces the high vacuum required; all other mechanical means tried so far have failed to maintain sufficient vacuum, and the chemical means are beyond commercial application. This ejector consists of two parts, each of which has a different function, namely, the steam nozzles for transforming potential into kinetic energy, and the diffuser F for compressing the mixture of steam and vapor or reconverting the kinetic into potential energy. The pressure of the steam is converted into velocity in the nozzles; the steam, leaving the nozzles at a very high velocity, carries with it the vapors coming from the evaporator, and the mixture of steam and vapor, being of a lower pressure than that existing in the condenser, must be compressed to the latter pressure, and this is done in the diffuser, thereby converting a part of the velocity into pressure.

the temperature to be produced is 50 deg. F. below the one in the condenser, one ejector is sufficient. The condenser temperature is almost solely dependent upon the temperature of the cooling water and in well-designed condensers is about 5 deg. F. higher than the water circulated. For a greater temperature difference, say one of from 70 to 100 deg. F., two ejectors are required, compressing the vapor in two stages.

However, two ejectors are not economical, and while it is easy to produce temperatures of from zero to 10 deg. F. below zero, the commercial application of the water-vapor refrigerating apparatus is practically limited to such temperatures as can be produced with one ejector. The two-ejector arrangement may be used to advantage where complete safety or some other advantage outweighs poorer economy as compared with other systems.

Where an abundance of cooling water at pumping heads smaller than the one required for a cooling tower is at hand and the condenser discharge may be wasted, as in all marine installations, a cooling tower is not required.

Any well-designed cooling tower may be employed, the only difference between its use in this process and for an ordinary refrigerating plant being in the application of the

makeup water. Ordinarily, it is simply added to the condensing-water supply, whereas in this process it is first used to advantage as makeup water in the surge tank and also as cooling water in the coil of the air-pump sealing-water cooler, from which it is pumped to the cooling tower with the bulk of the circulating water. As shown in Fig. 2, the brine-, air- and water-circulating pumps are all driven by a common shaft, which may be operated by any kind of high-speed prime mover.

The apparatus as a whole offers advantages over the old forms of refrigerating apparatus for certain fields of application. It requires practically no foundations, takes less floor space and less buildings than ammonia compression or absorption systems, and in larger units its first cost is less than that of any other system.

The wear and tear is slow, and consequently repairs are few, as only the prime mover, together with the three pumps, all of which are of the centrifugal type and devoid of wearing surfaces except the bearings, form the moving machinery.

As no chemicals are used, the cost of recharging, as well as the loss by leakage and accident, is eliminated. Pressure

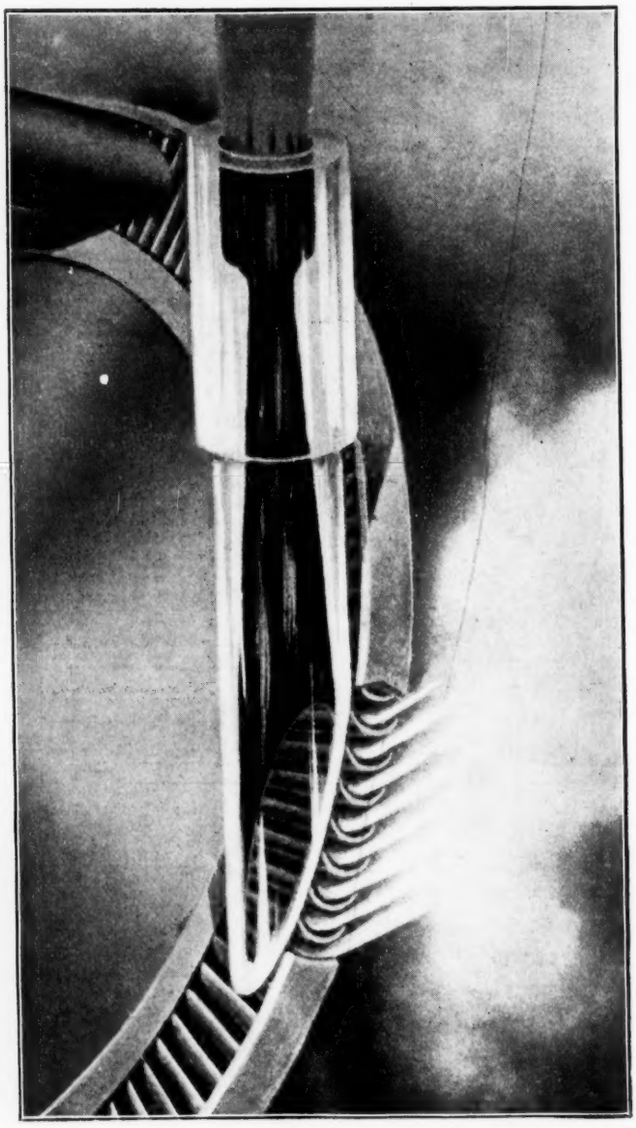


FIG. 3. THE DE LAVAL TURBINE NOZZLE

higher than that of the atmosphere is not produced, therefore there is no danger of explosion, and a less-skilled attendant is required than with ammonia plants.

For operating the ejector, either exhaust steam or live steam of any pressure can be used, but it must be dry, as water carried with the steam reduces the efficiency of the ejector nozzles. Common salt or calcium chloride may be used for the brine, but the latter is preferable because, being neutral, it does not act on the metals of the apparatus.

Ordinarily, the economy of a refrigerating machine is judged by the horsepower required per ton of refrigeration. This may mean anything between 10 and 100 lb. of steam per hour, depending upon the prime mover employed. The type of boiler used also has its effect on the real economy. The steam-jet process of refrigeration uses the steam differently from other systems, and a fair comparison can be had only by going back to the source of energy—heat.

For producing very low temperatures with one ejector only, another new process may be mentioned, but details can-

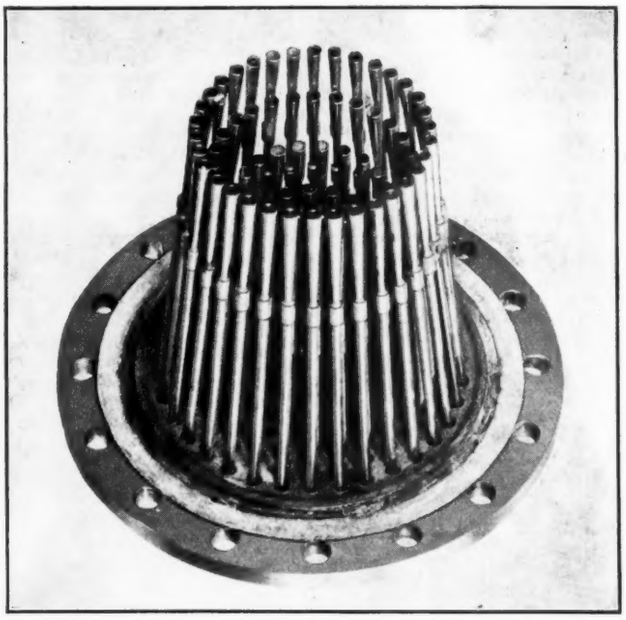


FIG. 4. STEAM NOZZLE USED IN EJECTOR

not be given at present. This latest process is the author's discovery and consists of a somewhat similar apparatus, operating with a steam ejector and using a chemical that is as harmless as water, not very expensive, and that condenses at atmospheric pressure. The experiments carried on so far are promising. With an apparatus limited to 28.5 deg. F. while operating with water vapor and one ejector, with the new process a temperature of —18.5 deg. F. has been obtained. Either exhaust or live steam can be used, in the same manner as with the water-vapor apparatus.

Auxiliary Turbines on Shipboard

At the recent annual meeting of the Society of Naval Architects and Marine Engineers, W. J. A. London and Frederick B. Herbert presented a paper entitled "The Application of Small Steam Turbines for Auxiliary Purposes on Shipboard." The paper deals chiefly with the history of the small auxiliary turbines for marine use, and from it the following excerpts are taken.

Referring to the use of blowers, the authors state that it is interesting to note the lack of knowledge relative to high-speed fans for high capacities when their application was first considered for marine use. At that time one of the first fans was guaranteed to run at 2,500 r.p.m. and to require 30 hp. After several disheartening attempts at procuring a reliable fan, a successful one was built, but the speed had by this time dropped to 1,700 r.p.m. and the horsepower had increased to 60. The efficiency of the first fan was in the neighborhood of 25 per cent. Today this efficiency has been increased to 50 per cent.

Since 1910 the capacity and air pressure have increased with the increased horsepower of new torpedo-boat destroyers, so now the standard for two of these boats now in service is 32,000 cu.ft. per min. against 6 in. air pressure. This has been obtained without increasing the diameter of ventilators, by improvements in turbine and fan efficiency. The static pressure in the fireroom and greater capacity have increased the peripheral speed of the fan to such an extent that now the type selected is in part determined not only by its efficiency, but by the noise it makes, as excessive noise is a tactical disadvantage to a destroyer. The type of fan has

evolved from the original Sirocco to the cone type and thence back to the multiblade, with blades that will run quietly. Originally, with oil fuel for destroyer service, a ratio of 225 cu.ft. per lb. of oil was considered to be correct; now 350 cu.ft. per lb. is standard.

Little authentic information could at first be obtained from the fan builders as to the true performance of the fans, and therefore there was nothing left to do but to run comparative tests. There are now, in all, 46 oil-burning destroyers with turbine-driven forced-draft fans, each with four complete units.

In speaking of centrifugal pumps for shipboard service the authors state: "Within reasonable limits the efficiency of the turbine matters little in the over-all fuel costs, as the heat rejected can be turned to useful work, but in the driven machine anything below 100-per cent. efficiency must be considered as a dead loss." This has introduced the use of gears. The noise created by an imperfect gear in the confined spaces on shipboard must necessarily be more disagreeable than in a large power house, and this, considered together with the really small saving in the over-all economy, leaves the writers skeptical as to the net advantages. Two of the sister battleships now building, the "Idaho" and the "Mississippi," are equipped with direct-connected and geared circulating pumps respectively, and some interesting comparative results should be forthcoming. The comparative cost of upkeep after twelve months of operation will be welcomed.

Practically all small turbines expand the steam in the initial jet to a point below the critical velocity, so that Napier's formula for the flow of steam will give results as accurate as any weighing or measuring method and probably more so. All that is necessary is an accurate gage placed in the steam ring and a record taken of the dimensions of the throats of the jets. It will be found that all makers of small turbines are particular as to the design, shape and dimensions of the jet being made to accurate plug gages, so that the dimensions of the jets can be relied upon. Napier's formula reads $W = \frac{PA}{70}$, where W is weight of steam per second, P the absolute pressure before the jet in pounds per square inch, and A the area of the jet in square inches.

From experience it has been found that for the majority of small turbine work and the small jets necessary for the expansion of high-pressure steam, a coefficient of 72 is more accurate than 70, and this in turn simplifies the formula given for the flow of steam per hour as follows: $W_1 = 60\ PA$, where W_1 is the pounds of steam per hour.

Load-Dispatching Systems

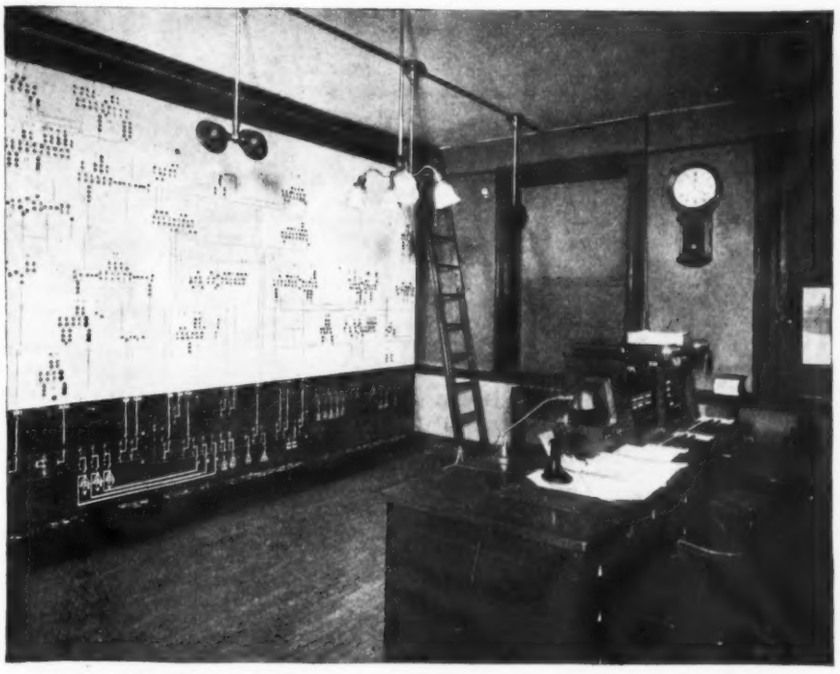
SYNOPSIS—Description of the load-dispatching system in use by the Boston Edison Co. and a discussion on the duties of the load dispatcher based on the practice of the Public Service Electric Co.

Owing to the growth of the alternating-current network of interstation lines, it is deemed advisable by many large companies to have a system wherein the control of this network and all orders in connection with its operation are concentrated under a load dispatcher. An instructive paper describing the system of the Boston Edison Co. was recently read by P. J. Kent before the Boston Section of the American Institute of Electrical Engineers and discussed by J. T. Lawson, who had earlier read a paper before the Philadelphia Section of the same society on "Load Dispatching," based on the practice of the Public Service Electric Co. of New Jersey. Mr. Kent's remarks were in part as follows:

The load-dispatching quarters are on the third floor of the office building at the L Street Station, South Boston. These consist of two rooms, one of which is fitted up as a living room, being equipped with two beds, a couch, clothes closets and the necessary number of chairs, etc.; there is also a kitchenette. This furnishes a convenient place where the men can be housed and fed in case an emergency arises where their services are likely to be needed at once. The other room contains the load dispatcher's board, upon which are the diagrams showing the generating, transmission and transforming equipment both at the generating stations and substations, also all tie lines between the substations. It does not include any of the distributing systems, this not being deemed necessary, as it would tend to complicate the board.

One section of the board covers the west side of the room and contains the 6,900- and 13,800-volt diagrams; the small section on the south side of the room at right angles to this section contains the 2,300-volt diagrams. On the west wall there is also a blue-marble board upon which are mounted alternating-current voltmeters and frequency indicators connected with the main and auxiliary busses, and also direct-current voltmeters connected to the three sections of the exciter bus. The upper part of the load dispatcher's board is of wood painted white and the lower part is of slate and other fireproof material. The diagrams for the substations are laid out on the wooden section and that of the generating station on the lower slate section; the busses are indicated by red lines. Transmission lines and units on the upper section are indicated by black lines and symbols, and on the lower section by white. The disconnecting switches are represented by black-topped plugs and the oil switches by red-topped plugs which fit into proper receptacles, except for the generating station at L St., where they are shown by telephone switchboard lamps under green lenses. These latter are automatically lighted when the oil switches are closed and extinguished when the oil switches are opened, by means of movable contacts on the switches.

The 20-volt current for these lights is supplied by two motor-generator sets, the motors being operated from the 125-volt exciter bus. This is for protection, as the exciting system is supplemented by two batteries of large capacity, thus furnishing a continuous supply in case of accident to the motor-driven exciters. The lighting of the load dispatcher's room is so arranged that it is possible to operate it from the alternating-current supply or the exciter bus.



ONE END OF THE SYSTEM BOARD IN THE LOAD-DISPATCHING OFFICE

On the 2,300-volt section are shown the busses and connecting lines for eight substations, on the 6,900-volt for 15 and on the 13,800-volt for 22. Also on the latter section is shown a

9,000-kw. frequency changer with its necessary switches and two 13,200-volt lines connecting with the Boston Elevated Railway Co.'s station at the foot of O St., South Boston.

A two-position telephone board furnishes the means of communication, each station being supplied with a direct line from this board, also with an outside line. The operators, when sitting at the desk or telephone board, have a clear view of the diagram of the system as laid out on the board. The photograph, for which we are indebted to "Edison Life," shows one end of the system board.

Handling of the system is taken care of by four load dispatchers—one for each 8-hr. watch, and the fourth a spare who, when not on duty as load dispatcher, helps out in a general way in the operation of the L Street Station. In addition there are three regular telephone operators, whose hours of duty are the same as those of the load dispatchers. There is also a spare operator, who acts as clerk to the chief system operator when not employed on the telephone board.

DUTIES OF THE LOAD DISPATCHER

The men selected as load dispatchers are naturally of more than ordinary ability, particularly those that have come up through the various grades and understand the system thoroughly. Some of their duties are as follows:

1. Approving all permits for work to be done on transmission lines, also in all stations, whether on busses or apparatus.
2. Permits for work on commercial services have to be first approved by the electrical engineering department and then by the load dispatcher. Before the work designated on these permits can be started, the load dispatcher has to be notified, so that he can arrange the system in such a way that the line or apparatus can be taken out of service. After being taken out of service, properly tagged and protected under his direction, the work designated can proceed. After the work is completed, all tests are directed by him, the phasing of lines is done under his orders, and finally the line, service or apparatus is put back into service under his direction and normal conditions of operation resumed.
3. Arrangements for all tests and routine work in stations by the department of standardizing and testing, also for all high potential tests on lines and services.
4. Receiving reports of all troubles in stations whether on apparatus or service; tabulating and reporting same to all departments concerned.
5. Giving advice to substation operators to help overcome troubles that may arise.
6. Directing all changes on the system for the purpose of taking out lines for the maintenance department under normal or emergency conditions. If the emergency is urgent, such as would endanger life or property, then the line can be taken out by direct call to the station where it originates. The load dispatcher must be communicated with as soon as possible, however, so that he can arrange to have other services that may be disarranged on account of this emergency properly restored.
7. Furnishing daily reports to the generating department office, giving all important happenings, whether trouble or otherwise, to the generating, transforming and distributing systems.
8. Another very important duty of the load dispatcher is to see to the economical loading of all generating and transforming apparatus.

Mr. Lawson's remarks, as well as the salient points of his former paper, are embodied in the following:

Some companies operate the control boards by hand, using a scheme of wooden plugs or metal tags of various colors; others operate them electrically, either automatically or manually, with colored pilot lamps, which give an indication of the apparatus and the lines in service. Also, to transmit operating orders from the load dispatcher to the operator, in addition to the telephone, some companies employ telautographs, pneumatic tubes and automatic signal systems.

PRECAUTIONS WHEN WORKING ON APPARATUS

All requests for rendering cables, lines and apparatus unavailable should, wherever possible, be made in writing to the load dispatcher at least twelve hours previous to starting the work, on a regular form provided for the purpose. Telephone requests for work of this character should be confirmed by written form, and they should be allowed only in emergency cases.

Before work is started on any apparatus, cable or line, all the switches should be opened, the lines and apparatus tested for potential, and if dead on test, they should be grounded and short-circuited with a grounding device of sufficient capacity to carry safely the short-circuiting currents that are likely to be thrown on. Also, a tag should be placed on the control switches at each end of the line and on the load dispatcher's operating board, each tag carrying the complete history of the work and the names of the men doing it. The name of the operator who is responsible for the switching and placing of the safety devices should appear on the tag, and a tag should be made out for each foreman working on the job. Furthermore, all telephoning regarding such cases must be repeated word for word to prevent error. A complete record of all such work should be kept by the load dispatcher and the switchboard operator, in a logbook provided for the purpose.

Tags, after use and after being properly filled out, are sent to the load dispatcher, who will keep them for at least three months, at the end of which time they can be destroyed or kept, as seen fit.

The equipment furnished the load dispatcher should be arranged so that in the event of trouble the system operator can clear it as quickly and safely as possible. Also the load dispatcher should have the proper support and organization behind him. He should report and be controlled directly by the operating superintendent. All switchboard operators and station engineers, so far as actual operating subjects are concerned, should come under the direction of the system operator.

The operating board should be placed where it can be seen from all parts of the office, and built in such a manner that it can be readily enlarged from time to time as the system changes. It should include a diagrammatic layout of the generating system, so as to show all generators and other apparatus, busses and lines, together with the switches. Preferably, the board should operate automatically as the switches or lines are thrown in and should be equipped with pilot lamps to show that the oil switch is in, and show that there is potential on the cable. With these two indicating lamps the dispatcher is able to make switching changes more quickly than with one lamp or without any indicator at all, especially where large generating stations are run in multiple. It is also possible to secure an indicating device that will show whether or not a knife-switch has been left open when changes have been made. Furthermore, recording devices should be installed that will automatically record the movements of the switches on a paper tape. These are of great value in running down troubles where a proper sequence of events is necessary to arrive at the correct solution of the trouble.

Each station switchboard should be equipped with automatic indicating devices that will show immediately when the switches release, also pilot lamps that will indicate if an incoming or outgoing feeder is alive. The load dispatcher should keep a record of all operating and routine switching changes in the logbook.

RING VS. RADIAL FEEDER SYSTEM

There are several methods of arranging a cable system with tie and parallel feeders, but they all narrow down to two main types, the ring and the radial. Undoubtedly, from a load-dispatching standpoint a radial system is the ideal one. Such a system with enough cables to give the proper factor of safety, arranged with reactors, selective relays, private telephones and signaling devices, would serve to reduce serious interruptions to a minimum, but unfortunately the cost of such a system is prohibitive; therefore, most companies use the ring system. However, most of the advantages claimed for the radial system can be obtained in the ring by equipping it with the proper relay switches, reactance and switching arrangements in the central station and substations. The ring system must be studied and the relays set very accurately to get the best results.

Economical service is an important part of a dispatcher's duties, and load-dispatching departments have been playing an important part in reducing operating costs. Each station and substation should plot a daily load curve and forward it to the load dispatcher, who will in turn plot a system curve. Also, by studying the characteristics of each generating station from the tests of individual units, a proper operating schedule can be made up that will give the best operating economy as a whole. In this manner the most economical units can be run to the best advantage and boilers can be banked and kept under steam as needed.

Another thing that the load dispatcher can do from the daily curve is to help the engineering department in its annual purchase of apparatus. By plotting curves from year to year, a percentage of normal increase of business is readily seen, and the load dispatcher is able to estimate a year or two ahead on the maximum demand for which it is necessary to purchase apparatus and furnish cables and lines to transmit their output.

Morin's "Laws of Friction"—(1) The friction between two bodies is directly proportioned to the pressure; that is, the coefficient is constant for all pressures. (2) The coefficient and amount of friction are independent of the areas in contact, pressure being the same. (3) The coefficient of friction is independent of velocity, although static friction (friction of rest) is greater than the friction of motion.

How To Make a Splice in Wire Rope*

Where wire rope is used, it often happens in case of a breakdown, that no one can be found on the job who can splice the severed ends, and naturally there is much time lost in securing some outside man to do the work. Splicing a rope is generally regarded as a mysterious process, whereas almost anyone can learn in a few hours how to do it. The illustrations show how a substantial wire-rope splice may be effected.

A hammer and a cold chisel for cutting off ends of strands, a steel fid or marlinspike for separating strands, two clamps for untwisting the rope, a sharp pocket knife for cutting the hemp core and a wooden mallet are all the tools needed. When starting to splice, proceed in this order:

First, lay the rope on the ground, with ends overlapping 20 ft., 10 ft. each way from the center, as indicated in the view given in Fig. 1.

Second, unlay the strands of both ends of the rope for a distance of 10 ft., as shown in Fig. 2. Cut off the hemp cores close up on both sides and bring the strands together so that the opposite strands will interlock regularly with each other.

Third, unlay strand 1a and follow up with strand 1 of the other end, laying it tightly in the open groove made by unwinding 1a; make the twist of the strand agree exactly with the twist of the open groove. Proceed with this until all but 6 in. of strand 1 is laid in or until 1a has become 20 ft.

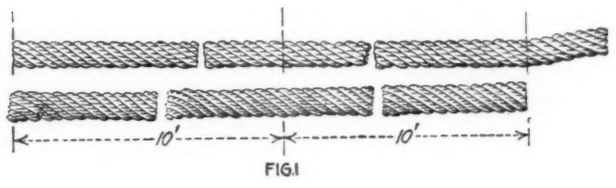


FIG.1

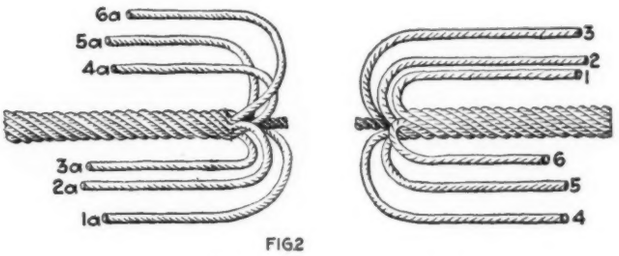


FIG2

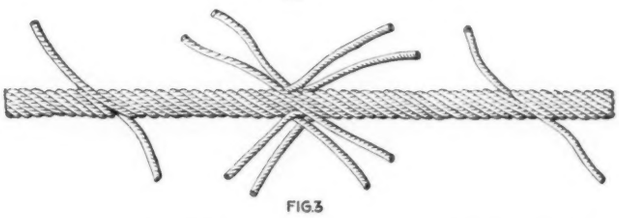


FIG3

long, then cut off the strand 1a, leaving an end about 6 in. long.

Fourth, unlay strand 4 of the opposite end and follow with strand 4a, laying it in the open groove as before, treating this as in the first case (see Fig. 3). Pursue the same course with 2a and 2, stopping 4 ft. short of the first set. Next do this with 5 and 5a, stopping as before, then with 3a and 3, and last with 6 and 6a. The strands are now all laid in with the ends 4 ft. apart, as shown in Fig. 4.

Fifth and last, the ends must be secured without enlarging the diameter of the rope. Take the two rope clamps, as shown in Fig. 6, and fasten them to the rope, as shown in Fig. 5. Twist them in opposite directions, thus opening the lay of the rope, as in Fig. 5. Next with a knife cut out the hemp core about 6 in. on each side. Straighten the ends and slip them into the place occupied by the core; then twist the clamps back, closing up the rope, and take out the slight inequality with the wooden mallet and a block of wood. Next shift the clamps and repeat the operation at the other five places, and the splice is made.

*By C. J. Fuetter, Logan, W. Va., in "Coal Age," Nov. 20, 1915.

New Type of Steam Safety Valve*

By George H. Clark

The safety valve described herewith is an attempt by the designer, first, to embody in a safety valve the equivalent of a standard orifice so that the discharge may be a maximum for any given discharge opening; secondly, to design a seat and lip of such shape that the maximum lifting force will be available without hampering the discharge; thirdly, to so arrange the parts that back pressure in the valve casing will have no effect on either the discharge capacity of any given opening or the opening itself.

According to the best information available, Prof. E. F. Miller of the Massachusetts Institute of Technology, was the first to round off the seat edge of a safety valve so that the discharge with the same lift should be increased. This same idea is to be found in the valve shown. If the radius of the curve of approach to the seat is equal to, or greater than, the maximum lift, the orifice is standard. In the belief that a flat seat is the equal of any other in keeping tight, it has been used, because of the greater discharge capacity per unit of vertical lift with this shape of seat.

From the seat outward the steam passage is directed upward, so that the area of the passage at any section, measured perpendicular to the mean direction of steam flow, is nearly equal to the area over the seat. The pressure at the throat of an orifice of this type is approximately 0.6 of the initial

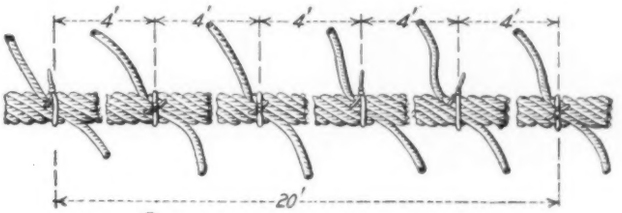


FIG.4

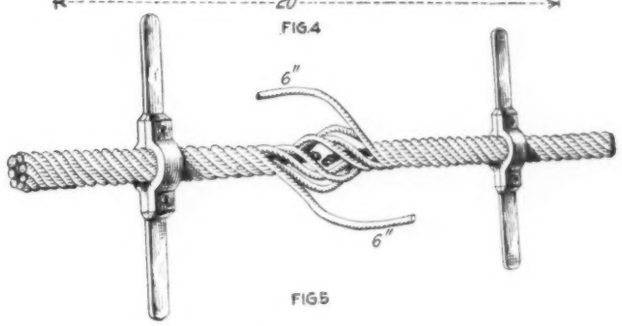


FIG5

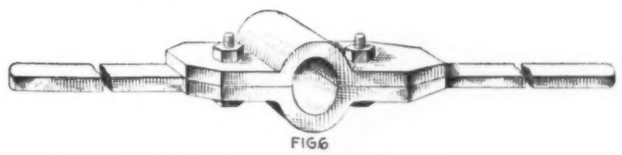


FIG6

FIGS. 1 TO 6. THE SUCCESSIVE STEPS IN ROPE SPLICING AND THE CLAMPS EMPLOYED

pressure, and if the area of each successive section is equal to the throat sectional area, the pressure will be equal to that at the throat and will be the maximum possible without reducing the volume of discharge over the seat. When the pressures are a maximum, the lifting force is, of course, a maximum on the exposed area.

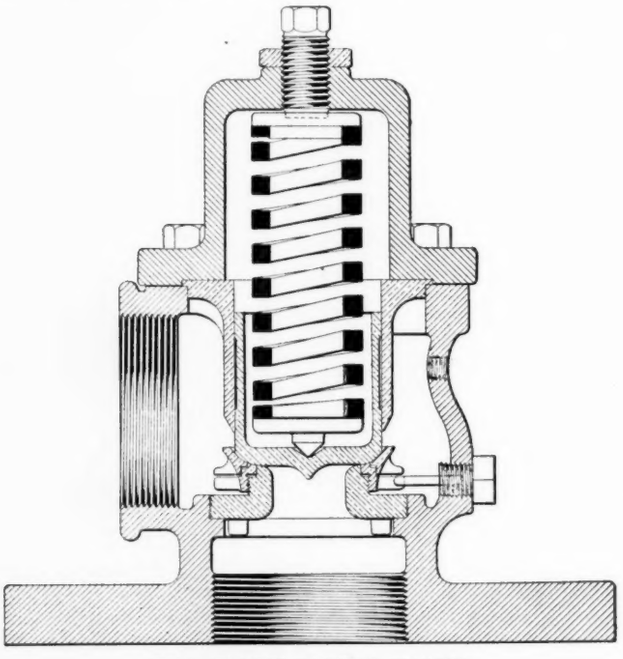
If the curves on disk and base were duplicates, the lifting force would be constant at all lifts if the boiler pressure was held constant. This arrangement would result in an enormous blowdown, and hence it is necessary to devise a way of reducing the lifting force at low lifts, and of producing an arrangement such that the lifting force increases as the lift increases. This can be accomplished by using two adjusting rings which allow of the area beyond the throat section being varied (which results in a corresponding variation in pressure), so that the desired effect is produced. The inner ring, being well up to the disk, provides a cushion of steam on which the valve seats on closing, which greatly reduces the shock.

*Abstract of a paper read before the December meeting of the American Society of Refrigerating Engineers. The abstract is by the author of the paper.

The amount of warning the valve has is determined by the position of the inner ring. The outer ring provides the larger part of the lifting force after a small lift has been produced by the inner ring. Like the present type of pop safety valve, the sustained lift is smaller than the pop lift, but the lift on this valve increases rapidly with accumulation of pressure.

The disk is guided from above by a cylindrical well extending down from the spring chamber, as shown in the illustration. It fits the well loosely and is long enough in relation to its diameter to prevent binding. This type of disk avoids the ill effects due to back pressure in the casing and has a tendency to increase the lifts when back pressure does exist.

The results of tests made at the Naval Experiment Station at Annapolis indicate discharge capacities as follows: All discharge-capacity tests were run at 6 per cent. accumulator



THE CLARK SAFETY VALVE

pressure, under which conditions a valve with a 2½-in. seat, opening at 200 lb. and blowing at 212 lb., discharged approximately 19,000 lb. per hr. A valve with a 2-in. seat, opening at 150 lb. and blowing at 159 lb., discharged 8,000 lb. per hr. The larger valve had a sustained lift of 0.23 in. and the smaller a lift of 0.15 in. under the above conditions. The larger valve gave a blowdown of 6 lb., closing at 194 lb. pressure. The smaller gave 3½ lb. blowdown at 150 lb. opening pressure, and when fitted with a heavier spring, showed the same blowdown at 200 lb. opening pressure. The warning was in either case less than one pound. Both valves seated firmly without chattering and with no appreciable shock. The smaller of the two valves was blown repeatedly with and without back pressure in the casing, and no appreciable change could be detected in warning, lift or blowdown. The back pressure was produced by partially closing a valve in the discharge line. The flat seat proved to be very efficient in preventing leakage.

Grooving in Certain Parts of Boilers has been largely eliminated by reducing the thickness of the parts affected. As is well known, there is a potential difference between strained and unstrained metal, and parts in tension tend to dissolve selectively if exposed to chemical action. An interesting experiment in this connection is recorded. A series of rings of mild steel was prepared, the inner diameter of one set being slightly less than the outer diameter of the others. The rings were shrunk together in pairs. The inner member of the pair was accordingly under compression and the outer under tension. The sets were then placed in a caustic evaporator for a period of several months. On final removal the outer rings were found to have become quite brittle, while the inner ones remained perfectly ductile. In comparison experiments, made with rings untreated chemically, both inner and outer rings retained their ductility.—From a paper by C. E. Stromeyer before the Manchester Steam Users Association.

PERSONALS

H. B. Niblette, general manager of the Buffalo Branch of the B. F. Goodrich Co., has resigned after having been connected with that company for 17 years. He will temporarily make his headquarters at the Knickerbocker Hotel, New York City, beginning Jan. 3. Definite announcement of his plans is not given at this time, other than that he is considering fields of larger and broader opportunities. No successor has been named, but an appointment will probably be made in a few days.

Paul M. Lincoln, whose connection with the Westinghouse companies in their operating and engineering activities dates back for over 23 years, as of January 1, 1916, becomes associated with the sales organization of the Westinghouse Electric and Manufacturing Co., with the title of commercial engineer. Mr. Lincoln is well known in engineering circles through his active work in the American Institute of Electrical Engineers, of which he is a past president. He is a well-known writer on technical subjects and has also been identified with educational work for some time, filling the chair of professor of electrical engineering of the University of Pittsburgh. He was graduated from the Ohio State University in 1892.

T. W. Ransom, consulting mechanical engineer of the Board of Public Works of San Francisco, has tendered his resignation to M. M. O'Shaughnessy, city engineer, to take effect Jan. 1, 1916, in order to return to his former private practice as consulting engineer, with offices at 1104 Merchants Exchange Building. For eight years Mr. Ransom has been actively associated with the City Engineering Department on the design of the high-pressure fire-protection system, which is the most elaborate and efficient in the United States, and on the municipal street-railway system, which has proved even more successful than its proponents predicted. Previous to his engagement by the city, Mr. Ransom was instrumental in perfecting and developing the impulse waterwheel to its present high efficiency. He designed the hoisting works and air-compressor plants of some of the largest mines in California.

Trygve D. Yensen, first assistant in the Engineering Experiment Station in the department of electrical engineering of the University of Illinois, was promoted Jan. 1, 1916, to research assistant professor of electrical engineering, because of his success in the development of alloys of iron possessing remarkable electrical properties. He was graduated from the University of Illinois in 1907 with the degree of Bachelor of Science in electrical engineering, received the degree of Master of Science in 1912 and of Electrical Engineering in 1913. The thesis which he submitted in partial fulfillment of the requirements for the bachelor's degree won for him in 1907 the Edison Medal conferred by the American Institute of Electrical Engineers. After graduating he served for a time in the testing department of the General Electric Co., of Schenectady, N. Y., and later as assistant engineer of the Shawinigen Water and Power Co., of Montreal, Canada. In 1910 he became assistant in the Engineering Experiment Station in the department of Electrical Engineering of the University of Illinois.

BUSINESS ITEMS

H. Bratton, formerly with George I. Roberts & Bros., Inc., is now connected with the sales force of Cornell & Underhill, New York.

The Richardson-Phenix Co., Milwaukee, Wis., has opened a Chicago office at 562 W. Washington Blvd. W. L. Osborne hitherto attached to the home office has been placed in charge as manager.

The interests of the Morse Chain Co., of Ithaca, N. Y., for the territory including the states of North and South Carolina, will hereafter be taken care of by Mr. G. W. Pritchett, with headquarters at 805 Ashboro Street, Greensboro, N. C.

The Cling-Surface Company, 1049 Niagara St., Buffalo, N. Y., has issued a special calendar, dedicated to the National Association of Stationary Engineers, and as long as the supply lasts will gladly send a copy to any member who applies to them for one.

The fifth edition of "Making Heat Produce" has been issued by the Diamond Power Specialty Co., Detroit, Mich., builders of mechanical soot blowers to suit every type boiler. The newest edition is pocket size and its fourteen pages contain information that is of much interest and value to every one having to do with the care and operation of boilers. Copy will be sent on request.